WAVETEK

OPERATION

Model 85

50 MHz Arbitrary/Function Generator

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50 MHz Arbitrary/Function Generator

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SECTION 1

GENERAL INFORMATION

1-1. INTRODUCTION

This manual provides operation and maintenance information for the Model 85 Digitizing Arbitrary/Function Generator. Section 1 is a general description of the instrument. Sections 2 and 3 contain installation and operation instructions. IEEE-488.2 (GPIB) programming is explained in Section 4. Maintenance and performance checks are provided in section 5. The theory of operation is described in section 6. Section 7 outlines calibration and troubleshooting procedure. Section 8 contain tables of replaceable parts and recommended spare parts. Section 9 contains schematic and component location diagrams.

NOTE

This manual provides a complete description of all features and options which are available on Model 85. Therefore, several features that are described in the following paragraphs may not be installed in your instrument.

1-2. DESCRIPTION

Model 85 is an extremely high-performance programmable digitizing arbitrary/function generator. Model 85 combines three powerful instruments in one small package: function generator, arbitrary generator, and digitizer. It provides a variety of standard waveforms, to be used as test stimuli for different electronic devices. Model 85 is also capable of capturing and replaying random signals; having sampling rates to 50Msps and with 12 bits of resolution. Microprocessor-based, Model 85 is easy to set up for manual use. It is also simple to program in GPIB system environments.

The instrument is built in an all-round metal case for improved RFI and EMI shielding. It is housed in a size to fit half-rack enclosures. Despite its small size, Model 85 offers many features and functions, such as built-in digitizer, automatic phase locking, counted burst, internal trigger-generator, full implementation of the new IEEE-488.2 standard, SCPI language compatibility, and more. Model 85 guarantees high quality waveforms throughout the specified frequency range, amplitude span, and operating temperature.

Model 85 covers a frequency range from 10mHz to 50MHz and an amplitude span from 10mV to 32Vp-p. Such broad coverage warrants a variety of complex applications. Rapid, repeatable testing every time is assured by a non volatile memory. Up to 10 front panel setups can be stored and recalled for later use; ensuring exact duplication of previous tests and status. Its performance, programmability and economy make it equally at home in every laboratory.

Model 85 features self-calibration and self-diagnostic functions that can be operated anytime from the front panel or by a GPIB command. The self-calibration function compares the output signal parameters to built-in internal references and stores correcting factors in special tables. If calibration routine fails or cannot be completed due to electrical faults, the generator produces a failure list.

Besides its normal continuous mode, Model 85 offers a variety of interrupted and controlled modes. Output waveform may be gated, triggered, or may generate a counted burst of output waveforms. A built-in trigger generator, having a programmable period, can replace an external trigger stimulant. The MANUAL trigger is just an additional convenience for front panel operation. The generator may also be placed in several externally controlled modes, such as VCO, FM, AM.

Model 85 may be used as an independent sweep generator with its output swept over an exceptionally wide range of 10 decades. The instrument offers a choice of eight sweep modes, both linear and logarithmic to cover a large number of applications. A MARKER output provides an oscilloscope Z-axis modulation to intensify segments of sweep trace.

Alternately, Model 85 may also be used as a standalone phase locking generator. The instrument locks automatically to an external signal and equates its output frequency and phase to that provided by the external reference. The operator may then divide the locked frequency by an integer number to 65535, and generate a phase offset between the reference signal and the generator's output. Phase offset is adjusted within a range of ±180°.

Model 85 provides an output level from 20mV to 32Vp-p into open circuit or 10mV to 16Vp-p into 50Ω. DC offset plus amplitude are independently variable within two window levels: ±16V and ±1.6V (into open circuit). This special characteristic allows generation of extremely small signals, at elevated DC levels.

Model 85 is capable of generating arbitrary waveforms with 12 bits of resolution. There are a few standard waveforms which are memory-resident. Other waveforms may be generated manually, using front panel controls; externally, using digital oscilloscopes; or through the built-in digitizer. Waveforms may also be generated on a computer (DOS version only) and downloaded to the instrument through GPIB or RS232 links. The wave generation software package - WaveCAD, is supplied free of charge with the GPIB option.

The arbitrary memory may store waveforms up to 32K long. If smaller size portions are needed, the memory may be divided to 99 smaller segments. A built-in circuit controls the sequence and the number of times that each segment is replayed. The sequencer circuit, operating at a sampling rate of 50Msps can generate extremely long waveforms which, otherwise, require much larger memory size.

The built-in digitizer eliminates the need for external devices to capture signals. The instrument can capture any external signal with 12 bits of resolution and with sampling rates to 300Ksps (20Msps 10bit, optional). The captured signal is stored in the non volatile memory and may be modified, resized, sequenced, and replayed with other memory segments.

1-3. INSTRUMENT & MANUAL IDENTIFICATION

The serial number of the instrument is located on the rear panel of the instrument. The two most significant digits identify instrument modifications. If this prefix differs from that listed on the title page of this manual, there are differences between this manual and your instrument.

Technical corrections to this manual (if any) are listed in the back of this manual on an enclosed MANUAL CHANGES sheet.

1-4. OPTIONS

Model 85 offers a few options: rack mounting option, designated as OPT -RACK and GPIB option, designated as OPT -GPIB. Options are field installable or may be ordered with new instruments from the factory. Installation procedures for the GPIB option are given in Section 7 of this manual.

1-5. SAFETY CONSIDERATIONS

Model 85 has been manufactured according to international safety standards. The instrument meets VDE 0411/03.81 and UL 1244 standards for safety of commercial electronic measuring and test equipment for instruments with an exposed metal chassis that is directly connected to earth via the power supply cable. Before the instrument is switched on, make sure that protective earth terminal is connected to a protective earth via the power cord. Do not remove instrument covers when operating or when power cord is connected to mains.

Any adjustment, maintenance and repair of the opened instrument under voltage should be avoided as much as possible, but when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

1-6. SUPPLIED ACCESSORIES

Model 85 is supplied with ac power cord and with an instruction manual. Extra manual is available on request.

1-7. SPECIFICATIONS

Instrument specifications are listed in Tables 1-1. These specifications are the performance standards or limits against which the instrument is tested.

NOTE

All specifications in the following table apply under the following conditions: Main signal output terminated into 50Ω, within ±5°C and 24 hours of last internal calibrations, and after 30 minutes of warmup time within a temperature range of 0 to 50°C.

Table 1-1. Model 85 - Function Generator Specifications.

WAVEFORMS:	Sine, Haversine, Havercosine, Triangle, Havertriangle, Square, Positive Pulse, Negative Pulse, Arbitrary.
FREQUENCY CHARACTERISTICS	
Range:	10.00mHz to 50.00MHz.
Resolution:	4 digits
Accuracy:	
Continuous Mode:	±3% of reading, from 10mHz to 999.9mHz; ±0.1%, from 1.000Hz to 50.00MHz;
VCO, FM, and Interrupted Modes:	±3% of reading, to 50.00MHz.
Jitter:	<0.1% ±50ps.
WAVEFORM CHARACTERISTICS	
Sine Wave	
Total Harmonic Distortion:	<1%, from 10.00mHz to 1.000MHz.
Harmonic signals below the carrier level:	>40dB, 1.000MHz - 5.000MHz, for amplitude from 10.0mV to 16.0Vp-p;
	>30dB, 5.000MHz - 50.00MHz, for amplitude <12.0Vp-p;
	>23dB, 5.000MHz - 50.00MHz, for amplitude >12.0Vp-p.
Flatness:	±1%, 10.00mHz to 999.9KHz;
	±2%, 1.000MHz to 9.999MHz;
	−15%, 10.00MHz to 50.00MHz.
Triangle	
Linearity (10% to 90% of amplitude):	<1%, 10.00mHz to 5.000MHz;
	<3%, 5.000MHz to 20.00MHz;
	<8%, 20.00MHz to 50.00MHz;
Flatness:	±3%, 10.00mHz to 999.9KHz;
	±5%, 1.000MHz to 9.999MHz;
	−25%, 10.00MHz to 50.00MHz.
Square Wave, Pulse:	
Rise/Fall time:	<6ns, 10% to 90% of amplitude (5 ns typical).
Aberration:	<3%.
SYNC Pulse:	
Output Level:	0 to 2.4V, into 50Ω; 0 to 4.8V, open circuit.
Rise/Fall time:	<6ns, into 50Ω.
Aberrations:	<5%.
OUTPUT CHARACTERISTICS	
Output Stand-by:	Output Normal or Disabled.
Impedance:	50Ω, ±1%.
Output Level:	20.0mV to 32.0Vp-p, into open circuit; 10.0mV to 16.0Vp-p, into 50Ω.
Resolution:	3 digits.
Accuracy (1 KHz):	±3% of reading, from 10.0mV to 16.0V.
Level Windows:	±800mV, for amplitude from 10.0mV to 99.9mV;
	±8V, for amplitude from 100mV to 16.0V.
Output Protection:	Protected against continuous short to case ground.

Table 1-1. Model 85 - **Function Generator** Specifications (continued).

Offset	
Resolution:	3 digits
Range:	Offset and amplitude are independently adjustable within level windows of ±800mV and ±8.00V.
Within ±800mV	0 to ±795mV;
Within ±8V	0 to ±7.95V.
Accuracy:	±(1% of setting + 1% of amplitude + .2mV), within ±800mV; ±(1% of setting + 1% of amplitude + 2mV), within ±8V.

TRIGGERING CHARACTERISTICS

Trigger Input:	Via TRIG/REF BNC terminal.
Impedance:	10KΩ, ±5%.
Sensitivity:	600mVp-p, to 60MHz.
Max Input Voltage:	±20V
Min Pulsewidth:	10ns.
Slope:	Positive or negative going leading edges, selectable.
Source:	Manual (front panel push button), internal, or external stimulant.
Modes	
Normal:	Continuous waveform is generated.
Triggered:	Each input cycle generates a single output cycle.
Internal Trigger:	An internal timer repeatedly generates a single output cycle
Gated:	External signal enables generator. First output cycle synchronous with the active slope of the triggering signal. Last cycle of output waveform always completed.
Counted Triggers (Burst):	Preset number of cycles (1-65535) stimulated by an internal, external, or manual trigger.
Internal Burst:	An internal timer repeatedly generates a burst of counted output cycles
Trigger Frequency:	
External:	To 50MHz.
Internal:	From 20μs to 999s;
Manual:	Simulates an external trigger signal.
Start Phase:	
Range:	Adjustable, from −90° to +90°, to 500.0KHz; proportionally reduced from 500.1KHz to 50.00MHz..
Accuracy:	±3°, to 500.0KHz
Trigger Level:	variable, −10.0Vto +10.0V.

LOGARITHMIC SWEEP CHARACTERISTICS

Modes:	Auto, Triggered, Gated and Burst. Output frequency repeatedly changes from start sweep to stop sweep settings. Available sweep directions are: up, down, up-down and down-up.
Width:	10 decades maximum.
Rate per Decade:	Continuously adjustable from 10mS to 999S, NOMINAL, per decade.
Steps per decade:	Depends on sweep time and range. Automatically adjusted for maximum steps per sweep time. Maximum steps are 200; minimum steps are 50.
Sweep Output:	1V/decade, below 5 decades; .5V/decade, above 5 decades.
Marker Output (Z axis):	0V with no marker; programmable from −0.10V to −5.00V, when
marker	frequency is reached and remains at this level until end of sweep.
Stop Sweep Resolution:	Same as Frequency resolution.

Table 1-1. Model 85 **Function Generator** Specifications (continued).

LINEAR SWEEP CHARACTERISTICS

Modes:	Same as in logarithmic sweep.
Width:	3 decades maximum.
Time:	Continuously adjustable from 10mS to 999S, NOMINAL.
Sweep Out:	0 to 5V, ±5%.
Sweep Steps:	Depends on sweep time and range. Automatically adjusted by the instrument to get the maximum steps per sweep time. Maximum steps are 1000; minimum steps are 2.
Marker Output:	Same as in logarithmic sweep.
Stop Sweep Resolution:	Same as Frequency resolution.

CONTROL CHARACTERISTICS

Modes:	VCO, FM, AM.
Input:	Via front panel CONTROL INPUT BNC connector.
Impedance:	10KΩ, ±5%.
Max Input Voltage:	±10V.

VOLTAGE CONTROLLED OSCILLATOR (VCO)/FM CHARACTERISTICS

VCO Sensitivity:	0V to −4.7V, ±20% produces 1/1000 frequency change from main frequency when main frequency is set to 9999 counts.
FM Sensitivity:	0V to 0.5V ±70mV, modulates to 1% deviation from center frequency.
Modulation Bandwidth:	DC to 50KHz.

AMPLITUDE MODULATION (AM) CHARACTERISTICS

Input:	DC coupled.
Input impedance:	10KΩ, ±5%.
Bandwidth:	DC to 1MHz.
Range:	0 to 200%; reduced to 70% at 1MHz.
Sensitivity:	0V to 5V produces 100% modulations; 0V to 10V produces sup-
pressed	carrier amplitude modulation (SCAM).
Envelop Distortion:	<1% for modulation depth <90%, carrier frequency <1.00MHz, and modulation frequency <50KHz; <3% for modulation depth <50%, carrier frequency <50.00MHz, and modulation frequency <50KHz

PHASE LOCK CHARACTERISTICS

Reference Input:	Via TRIG/REF BNC terminal.
Impedance:	10KΩ, ±5%.
Sensitivity:	600mVp-p, to 60MHz.
Max Input Voltage:	±20V (dc + peak ac).
Min Pulsewidth:	10ns.
Operation:	Output locks automatically to the frequency and phase of an external signal.
Locking Range:	10Hz to over 60MHz.
Dividing Ratio:	Programmable, from 1 to 65535.
Phase Offset	
Range:	Continuously adjustable from −180° to +180°, 10Hz to 19.99MHz.
Resolution:	1°
Accuracy:	±(3° + 3% of reading), 10Hz to 100KHz.

Table 1-3. Model 85 - **Arbitrary Generator** Specifications.

ARBITRARY WAVEFORM CHARACTERISTICS

Wavelength:	to 32768, programmable.
Vertical Resolution:	12 bits (4096 points).
Rise/Fall Time:	<7ns, 10% to 90% of amplitude.
Aberration:	<3%.
Sinewave	
Total Harmonic Distortion	(at 4096 vertical points and sampling rate of 50Msps): <0.05%, below 100KHz.
Harmonic Signals Below the Carrier Level	(at 4096 vertical points, below Nyquist frequency): >60dB, 100KHz to 1MHz; >50dB, 1MHz to 3.125MHz
Filter:	50KHz, 500KHz, 5MHz, 2 pole bessel type, selectable.
Residual Noise:	<4mVp-p, 0 to 20MHz bandwidth, at 10Vp-p and 50Msps.
Glitch Energy:	<200pV-s, at 10Vp-p
Glitch Width:	<4ns, at 10Vp-p

SAMPLING RATE CHARACTERISTICS

Range:	10.00msps to 50.00Msps. Defined as sampling rate, in sps; as frequency, in Hz; or as period, in s.
Resolution:	4 digits
Accuracy:	
Continuous Mode:	±3% of reading, from 10msps to 999.9msps; ±.1%, from 1.000sps to 50.00Msps;
VCO, FM, and Interrupted Modes:	±3% of reading, to 50.00Msps.
Jitter:	<0.1% ±50ps.

OUTPUT CHARACTERISTICS

Impedance, Level, Offset, and Accuracy:	Same characteristics as for function generator.
SYNC Output:	
Output Level:	0 to 2.4V, into 50Ω, 0 to 4.8V, open circuit.
Rise/Fall Time:	<6ns, into 50Ω.
Delay:	0 to 32766 clock cycles, limited by the selected segment size.
Marker Output (Z axis):	0V, off; -0.10V to -5.00V, on.

TRIGGERING CHARACTERISTICS

Trigger Input, Modes, Level, Source, and Burst:	Same characteristics as for function generator.
Start Phase:	Not applicable.

AMPLITUDE MODULATION (AM) CHARACTERISTICS

Input:	DC coupled.
Impedance:	10KΩ, ±5%.
Bandwidth:	DC to 200Hz.
Range:	0 to 30%.
Sensitivity:	0V to 1.5V produces 30% modulations.

Table 1-2. Model 85 - **Arbitrary Generator** Specifications (continued).

MEMORY MANAGEMENT CHARACTERISTICS

Memory Size:	Memory may be divided to 99 variable-size segments. Minimum segment length is 0 words; maximum segment length is 32766 words.
Memory Sequencing:	Memory segments may be re-arranged and multiplied in user definable order to create extremely long waves.
Sequencer Steps:	From 1 to 99, selectable.
Steps Repeated:	From 0 to 65535 times, programmable.
Step Duration:	100ns minimum, for more than 1 step.
Load Source:	
Digitizer:	Built-in digitizer captures external signals. Programmable sampling rate, amplitude window, and trigger control are provided.
WaveCAD:	Computer-aided program for generating complex waves, supplied with the GPIB option.
Front Panel:	Point-by-point data entry, or point-to-point autoline.
Saved Memory:	Waves stored in back-up memory may be recalled to the working memory. Information in memory cell includes segment size and wave table.
Standard Waveforms:	Built-in function tables include Sine, sin(x)/x, triangle, square, gausian pulse, exponential pulse, and noise.
Programmable Std. Waveforms Parameters:	
Wavelength:	16 to 8196 words.
Vertical Resolution:	16 to 4096 points.
Start Address:	1 to maximum size of segment.
Start Phase:	0 to 360° in 45° steps.
Duty Cycle:	1% to 99%, triangle and square waves only.
Memory Utilities:	Built-in utilities permit global operations on memory segments.
Clear Utility:	Clears a selected memory segment.
Fill Utility:	Fills a selected memory segment with constant data.
Offset Utility:	Offsets a waveform in a selected memory segment.
Copy Utility:	Copies a waveform from segment to segment.
Delete Utility:	Delets selected parts from memory segments.
Combine Utility:	Performs mathematical expression on two memory segments.
AM Utility:	Amplitude modulates a segment with sinewave.

Table 1-3. Model 85 - **Digitizer** Specifications.

DIGITIZER CHARACTERISTICS

Sampling Rate:	
Range:	10.00msps to 300.0Ksps.
Resolution:	4 digits.
Accuracy and Jitter:	Same as for function generator frequency.
Input:	Front panel BNC
Impedance:	1MΩ, ±5% parallel by 60pF.
Full Power Bandwidth:	150KHz minimum.
Vertical window:	±1V, ±2V, ±5V, selectable.
Vertical Resolution:	12 bits (4096 steps).
Digitizing Trigger Modes:	External, stimulated by an external signal; internal, stimulated by the input signal; manual, stimulated by a front panel push-button.
Trigger Level:	Internal, same as vertical window setting; external, from −10V to +10V.
Trigger Slope:	Positive going or negative going edges, selectable.
External Trigger:	
Range:	From DC to 5MHz maximum.
Sensitivity:	500mVp-p, NOMINAL.
Minimum Pulsewidth:	100ns ±10%.
Resolution:	3 digits.
Trigger Delay:	
None:	Digitizer starts data acquisition from where triggerred (address 0).
Pre-Trigger:	Digitizer starts data acquisition before triggered. The RAM is than re-arranged to include pre-trigger data.
Pre-Trigger Range:	0 to 32766 clock cycles, programmable.
Post-Trigger:	Digitizer starts data acquisition after triggerred. The RAM is than re-arranged to include post-trigger data.
Post-Trigger Range:	0 to 65531 clock cycles, programmable.

Table 1-4. Model 8553 - **General** Specifications.

ENVIRONMENTAL

Operating Temperature:	0° to +40°C, ambient.
Specified Accuracy:	Within ±5°C and 24 hours of last internal calibration.
Storage Temperature:	−40°C to +70°C.
Humidity range:	80% R.H.

GENERAL

Display:	2 lines, 16 characters, back-lit LCD.
Power:	115/230Vac, 50 or 60Hz, 120VA max.
Stored Set-ups:	Stores 30 complete sets of front panel set-ups.
Dimensions:	3.5" x 8.3" x 15.4" (H x W x L).
Rack Mount Dimensions:	3.5" x 19" (H x W).
Weight:	Approximately 12Lbs.

Table 1-5. Model 85 - **Options** Specifications.

GPIB INTERFACE (IEEE-488.2)

Interface Functions:	Complies with IEEE488.2, including queries and common commands.
Interface Protocol:	SCPI compatiable.
Programmable controls:	All front panel controls except POWER switch.
Subsets:	SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP2, DC1, DT1, C0.
Program Message Format:	Program Message Header, Program Data (floating point and/or suffix program data), Program Message Terminator. Characters lower or upper case.
Response Message Format:	Variable length response format consisting of Response Header, Response Data (NR1, NR2, or NR3 format), and Response Message Terminator.
Common Commands and Queries:	*CAL?, *CLS, *ESE, *ESE?, *ESR, *IDN?, *OPC, *OPC?, *RCL, *RST, *SAV, *SRE, *SRE?, *STB, *TRG, *TST?, *WAI.
Status Reporting:	*ESR?, *STB?, and RQS - read by Serial Poll.
String Termination:	Selectable NL, END (EOI) or combination of both.
Address Selection:	Front panel programming. Address stored in a non-volatile memory.

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SECTION 2

INSTALLATION

2-1. INTRODUCTION

This section contains information and instructions necessary for the installation and shipping of the Digitizing Arbitrary/Function generators - 85. Details are provided for initial inspection, power connection, grounding safety requirements, installation information, and re-packing instructions for storage or shipment.

2-2. UNPACKING AND INITIAL INSPECTION

Unpacking and handling of the counter requires only the normal precautions and procedures applicable to the handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to ascertain that the shipment is complete.

2-3. PERFORMANCE CHECKS

The instrument was carefully inspected for mechanical and electrical performance before shipment from the factory. It should be free of physical defects and in perfect electrical order upon receipt. Check the instrument for damage in transit and perform the electrical procedures outlined in Section 5. If there is indication of damage or deficiency, see the warranty in this manual and notify your local Wavetek field engineering representative or the factory.

CAUTION

It is recommended that the operator be fully familiar with the specifications and all sections of this manual. Failure to do so may compromise the warranty and the accuracy which Wavetek has engineered into your instrument.

2-4. POWER REQUIREMENTS

The function generator may be operated from any one of the following sources: a. 103.5 to 126.5 Volts (115 Volts, NOMINAL) b. 207 to 253 Volts (230 Volts, NOMINAL).

The instrument operates over the power mains frequency range of 48 to 63Hz. Always verify that the operating power mains voltage is the same as that specified on the rear panel voltage selector switch.

CAUTION

Failure to switch the instrument to match the operating line voltage will damage the instrument and may void the warranty.

The Model 85 should be operated from a power source with its neutral at or near ground (earth potential). The instrument is not intended for operation from two phases of a multi-phase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms) should be typically within the range of 1.3 to 1.6 at 10% of the nominal rms mains voltage.

2-5. GROUNDING REQUIREMENTS

To insure the safety of operating personnel, the U.S. O.S.H.A. (Occupational Safety and Health) requirement and good engineering practice mandate that the instrument panel and enclosure be "earth" grounded. All of Wavetek instruments are provided with an Underwriters Laboratories (U.L. and V.D.E) listed three-conductor power cable, which when plugged into an appropriate power receptacle, grounds the instrument. The long offset pin on the male end of the power cable carries the ground wire to the long pin of the Euro connector (DIN standard) receptacle on the rear panel of the instrument.

To preserve the safety protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to an "earth" ground.

CAUTION

To avoid operator shock hazard do not exceed the power mains voltage frequency rating which limits the leakage current between case and power mains. Never expose the instrument to rain, excessive moisture, or condensation.

2-6. INSTALLATION AND MOUNTING

The instrument is fully solid state and dissipates only a small amount of power. No special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 40°C, when the relative humidity exceeds 80% or condensation appears anywhere on the instrument. Avoid operating the instrument close to strong magnetic fields which may be found near high power equipment such as motors, pumps, solenoids, or high power cables. Use care when rack mounting to locate the instrument away from sources of excessive heat or magnetic fields. Always leave 4 cm (1.5 inches) of ventilation space on all sides of the instrument.

2-7. BENCH OPERATION

The Model 85 is shipped with plastic feet, tilt stand in place and ready for use as a bench or portable instrument. See outline drawing Figure 2-1 for outline dimensions.

2-8. RACK MOUNTING

The instrument may be rack mounted in a standard 19 inch rack. The instrument may be rack mounted in Rack Mount Kit option 85-rack.

2-9. PORTABLE USE

The instrument may be used in applications requiring portability. A tilt stand consisting of two retractable legs is provided with each unit.

2-10. SHORT TERM STORAGE

If the instrument is to be stored for a short period of time (less than three months), place cardboard over the panel and cover the instrument with suitable protective covering such as a plastic bag or strong craft paper. Place power cable and other accessories with the instrument. Store the covered voltmeter in a clean dry area that is not subject to extreme temperature variations or conditions which may cause moisture to condense on the instrument.

2-11. LONG TERM STORAGE OR RE-PACKAGING FOR SHIPMENT

If the instrument is to be stored for a long period or shipped, proceed as directed below. If you have any questions contact your local Wavetek field engineering representative or the Wavetek Service Department at the factory.

If the original Wavetek supplied packaging is to be used proceed as follows:

1. If the original wrappings, packing material, and container have been saved, re-pack the instrument and accessories originally shipped to you. If the original container is not available, one may be purchased through the Wavetek Service Department at the factory.

2. Be sure the carton is well sealed with strong tape or metal straps.

3. Mark the carton with the model number and serial number with indelible marking. If it is to be shipped, show sending address and return address on two sides of the box; cover all previous shipping labels.

If the original container is not available, proceed as follows:

1. Before packing the unit, place all accessories into a plastic bag and seal the bag.

2. For extended storage or long distance shipping only, use U.S. government packing method II C and tape a two-unit bag of desiccant (per MIL-D-3464) on the rear cover.

3. Place a 13 cm (5 inch) by 30 cm (12 inch) piece of sturdy cardboard over the front panel for protection.

4. Place the counter into a plastic bag and seal the bag.

5. Wrap the bagged instrument and accessories in one inch thick flexible cellular plastic film cushioning material (per PPP-C-795) and place in a barrier bag (per MIL-B-131). Extract the air from bag and heat seal.

6. Place bagged instrument and accessories into an oversized card-board box (per PPP-B-636 type CF, class WR, variety SW, grade V3C). Fill additional spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water resistant tape or metal straps.

7. Mark container "DELICATE INSTRUMENT", "FRAGILE", etc. Mark instrument model and serial number and date of packaging. Affix shipping labels as required or mark according to MIL-STD-129.

NOTE

If the instrument is to be shipped to Wavetek for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, the symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment. ALWAYS OBTAIN A RETURN AUTHORIZATION NUMBER FROM THE FACTORY BEFORE SHIPPING THE INSTRUMENT TO WAVETEK.

2-12. SAFETY

Be fully acquainted and knowledgeable with all aspects of this instruction manual before using the instrument to assure operator safety and protection against personnel shock hazard.

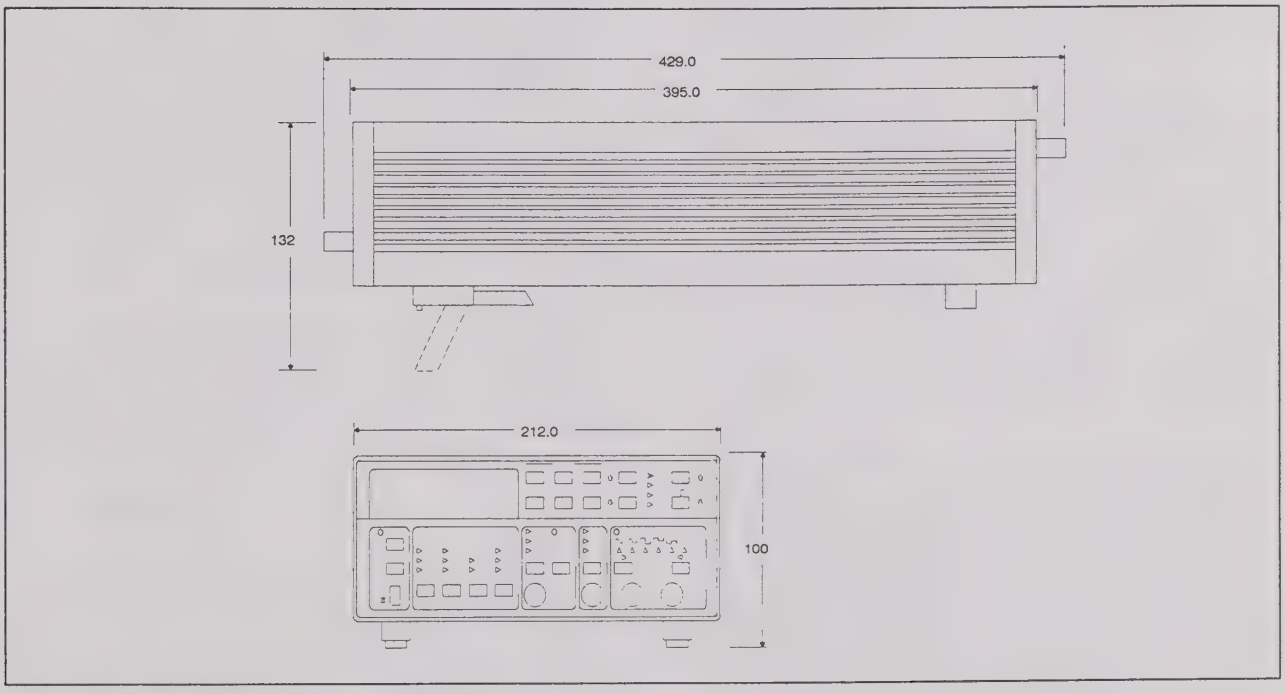

Figure 2-1. Model 85 - Outline Dimensions.

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SECTION 3

OPERATING INSTRUCTIONS

3-1. INTRODUCTION

Model 85 operation is divided into two general categories: basic bench operation, and IEEE-488 operation. Basic bench operation, which is covered in this section, explains how to use the model 85 for generating the required waveform characteristics. IEEE programming can also be used to greatly enhance the capability of the instrument in applications such as automatic test equipment. This aspect is covered in details in Section 4.

3-2. FRONT PANEL FAMILIARIZATION

The front panel is generally divided into three sections: controls, connectors, display and indicators. The following paragraphs describe the purpose of each of these items in details. Refer to the Model 85 front panel layout throughout the following descriptions.

3-3. CONTROLS

All front panel controls except the POWER switch and the vernier are momentary contact switches. Most controls include an annunciator light for indication of the selected parameter and operating mode. Some controls do not have an annunciator light. Exercising these controls generates an immediate response on the display.

Front panel controls may be divided into functional groups: Operating mode, State, Edit Menus, Digitizer Menus, Parameter Select/Edit, Trigger Modes, Control, Output and Modifiers.

3-3-1. Operating Mode

Two push-buttons in the operating mode group provide selection between four operating modes. Selection of one of the operating modes is done by depressing one of these buttons. The selected mode is indicated by an LED.

3-3-2. State

Three push-button are included in the status group. The function of each of these buttons is described in the following.

POWER - The POWER switch controls the AC power to the instrument. Pressing and releasing the switch once turns the power on. Pressing and releasing the switch a second time turns the power off.

2nd/HELP - Several push-buttons were assigned a second function which are only accessible after the [2nd] button was depressed. These functions are marked below the buttons in yellow script. Some second functions require that the [EXE] push-button be pressed again before the function is executed. The function of HELP is described later in this section.

LOCAL/TRIG/DCL - The LCL/TRIG push-button when depressed, and the instrument is placed in remote mode (but not in remote lockout condition LLO), will cause the instrument to go to local operating mode. When the generator is already in local operating mode, this push-button may be used to trigger certain functions. These functions are discussed later in this section. A third function is also assigned to this switch. DCL modifies front panel set-up to factory defaults. The function of DCL is described later in this Section.

3-3-3. Edit Menus

There are many parameters that control the operation of the model 85. These parameters are divided into functional groups and subdivided into menus. The use of menus in model 85, reduced dramatically the required number of push-buttons, which would otherwise be required to access all of the parameters.

The menus are divided into three functional groups: General Parameters, Arbitrary Wave Parameters, and Arbitrary Memory Parameters. The Edit Menus section includes three push-buttons. Each button is associated

with one of the above functional groups. Each time a button is depressed a different menu is displayed. The selected menu is indicated by an LED. Selection of the required parameter within a specific menu is done with the Parameter Select/Edit arrows. Selection and modification of various parameters is discussed later in this section. The following menus and parameters may be displayed and modified. Table 3-2 lists the limits for each of the these parameters.

3-3-3-1. General Parameters Menus

1. MAIN Menu

FREQ - Frequency of the selected output waveform. Frequency is defined for repetitive signals only. When the function generator is set to operate in triggered mode, the programmed frequency value has no effect on the output. In gated mode, the frequency defines the repetition rate within the gating signal. In continueous mode, the programmed frequency retains its value at both SYNC and the main output connectors. The frequency parameter may be programmed within the range of 10.00mHz to 50.00MHz. Preset value is set to 1.000KHz.

AMPL - Amplitude of the selected waveform at the main output connector. The output signal is driven from a 50Ω source therefore, the value of the amplitude parameter is specified and accurately controlled only when the output is terminated with 50Ω. If the signal from the output connector is connected to an high impedance circuit, the actual amplitude level at the output connector is doubled. Amplitude control has no effect on the amplitude level at the SYNC output connector. The amplitude parameter may be programmed within the range of 10.0mV to 16.0V. Preset value is set to 1.00V.

OFFS - DC offset of the selected waveform at the main output connector. Similarly to the amplitude, the offset parameter is specified and accurately controlled only when the output is terminated with 50Ω. Offset control has no effect on the SYNC output connector. The offset parameter may be programmed within the range of 00.0mV to ±7.95V. Preset value is set to 000mV.

MODULATION - Selects the external control option when the MODUL'N LED is turned on. There are four control options to select from: (0) No modulation, (1) Amplitude modulation, (2) Frequency modulation, and (3) VCO - Voltage Controlled Oscillator.

2. TRIG (Trigger) Menu

TRIG_LEV - The Trigger Level parameter sets the trigger voltage level at the TRIG IN connector. The external signal will trigger the function generator at the point set by the TRIG_LEV parameter. The trigger level parameter may be programmed within the range of −9.9V to +9.9V. Preset value is set to 1.6V.

TRIG_SLOP - The Trigger Slope parameter selects the edge sensitivity, at the TRIG IN connector, of which the instrument will trigger on. The operator may select to trigger on the rising edge (0), or on the falling edge (1) of the triggering signal. Preset value is set to trigger on the rising edge (0).

TRIG_PHAS - The Trigger Phase parameter determines the start phase of the output signal. The trigger phase has no effect on squarewaves and on positive/negative pulses. The trigger phase parameter has no effect on the arbitrary waveform. The trigger phase offset parameter may be programmed within the range of ±90°. Preset value is set to 00°.

TRIG_COUN - Model 85 is capable of generating a counted numbers of output waveforms (burst). The burst function operates on all output waveforms. The counted number of output cycles can be programmed within the range of 1 to 65535 output cycles. Preset value is set to 1 cycle.

INT_PER - A built-in generator provides an internal triggering stimulant in such cases where an external signal is not available. The displayed value specifies the interval between consecutive triggering sequences. The Internal Trigger Period parameter may be programmed within the range of 20μs to 999s. Preset value of the internal trigger generator is set to 1.00s.

3. SWEEP Menu

LIN/LOG_SWEEP ON/OFF - Selects the sweep steps option when the SWEEP LED is turned on.

SWEEP_DIR - When Model 85 is placed in sweep mode (linear or logarithmic), the selected waveform at the output connector repeatedly changes its frequency in a direction set by the sweep direction parameter. There are four different directions that the output waveform may sweep to: Up (0), Down (1), Up-Down (2), and Down Up (3). The difference between the various sweep directions is more significant when using the triggered sweep mode.

START - Defines the sweep start frequency. When the function generator is set to operate with one of its sweep modes, the waveform at the output con-

nector sweeps from frequency set by the START frequency setting to that set by the STOP frequency. In several sweep modes sweep stop may change its function to sweep start. The programmed frequency retains its value at both SYNC and the main output connectors. The Sweep Start parameter may be programmed within the range of 10.00mHz to 50.00MHz. Start frequency preset value is set to 1.000KHz.

STOP - Defines the sweep stop frequency. If the instrument is set to operate in logarithmic sweep mode, the sweep stop parameter may be programmed within the range of 10.00mHz to 50.00MHz. In linear sweep mode the sweep stop parameter may be programmed within three decades from the start frequency setting (when start frequency setting is programmed to 9999 counts). Stop frequency preset value is set to 9.999KHz.

TIME - In linear sweep mode, sweep time determines the time that it takes to complete one sweep cycle. Sweep time is different for logarithmic sweep mode where the specified value is that required for sweeping one decade. In logarithmic sweep mode, the generator may be progrsammed to sweep over 10 decades. In that case, the sweep time should be multiplied by ten. Decade size ranges from 1000 to 9999 display counts (or or proportional to 1000:1 if settings other than full and minimum scales are required). If only part of the decade is being swept, the sweep time is reduced proportionally. The sweep time parameter may be programmed within the range of 10.0ms to 999s. Preset value of sweep time is set to 1.00s.

MARK - Specifies the frequency of which the sweep marker changes its voltage level at the marker output connector. The marker output is only active when the function generator is set to operate with one of its built-in sweep modes. The sweep marker parameter may be programmed within the same range as the frequency stop parameter. Preset value is set in both linear and logarithmic modes to 5.000KHz.

4. PHASE Menu

Locked freq = EXT_REF/ddddd - Model 85, when placed in PLL operating mode, locks automatically to an external signal. The output of the model 85 then generates waveforms with the exact frequency and phase of the applied reference signal. The output frequency may be divided by a number set by the EXT_REF/ddddd parameter. Division ratio may range from 1 to 65535. For example, if Model 85 locks to a 1MHz reference signal and EXT_REF parameter is set to /100, the frequency at the output connector will be 10KHz. Preset value is set to 1.

PHAS_OFFS - Model 85, when placed in PLL operating mode, locks automatically to an external signal. The output of the model 85 then generates waveforms with the exact frequency and phase of the applied reference signal. A phase offset may then be programmed between the two first rising edges of reference signal and the output waveform. The phase offset is programmed with the PHAS_OFFS parameter. The phase offset parameter may be programmed within the range of ±180°. Preset value is set to 000°.

3-3-3-2. Arbitrary Memory Management Menus

1. SET-UP Menu

MEM_PART - This parameter defines the memory partition table for the arbitrary memory. The maximum available length of memory in this instrument is 32767 words. It is rare that one will want to use the complete range on one segment. Therefore, the memory may be divided to 99 smaller memory segments having memory length from 0 to 32767. Using the memory partition parameter, one can select the number of segments that he wants to use and their relative size in points. If more than one segment is selected, it is also possible to divide the memory to equal segments. The memory partition parameter defaults to 1 on preset and DCL (device clear).

SEG01 ddddd Pts - The length of the memory for each segment is selected with this parameter. This menu also displays the number of point that are still available for use either in the selected segment or in any other segment. DCL (device clear) sets this parameter to 32767.

2. LOAD Menu

SEG01_SOURCE - Following setting up the memory partition, one can proceed with selecting the what will be placed in each of the memory segments. The are a number of sources that can load the memory with waveforms: Built-in digitizer (0), built-in standard waveforms (1), and waveforms which were previously saved in the back-up memory (2). Use the SEG01_SOURCE parameter to select one of the required load source options from the above list. It is also possible of course to download waveforms from a computer or other auxiliary devices. These topics are discussed later in this manual. The

LOAD menu has a number of sub-menus to set parameters for each of the selected load source. These sub-menus and the load memory procedures are discussed in paragraph 3-23-3. DCL and preset select the built-in digitizer as load source for SEG01.

3. SEQU (Sequencer) Menu

SEQ_STEP - The total 32K word memory that is made available by the instrument may be divided into smaller memory segments. Each segment is then treated separately by the instrument, and may be replayed individually, repeatedly, or in sequence with other memory segments. The sequencer_steps parameter specifies for the instrument how many steps are sequenced. If the model 85 is placed in triggered mode, the sequence is repeated once or more; depending on the Trigger_Count parameter. When the instrument is placed in repetitive mode, the steps are repeated continuously. Preset value for the sequencer step is 1.

STEPdd - The maximum value of dd is automatically set to the selected number of steps in the previous menu. This parameter provides information on how many times each segment is repeated in one step. It is not necessary that segments be selected in specific order. One may define the sequence of segments according to his needs. The segment may be repeated from 0 to 65535 times. This means that one can turn segments on and off without the need to access the initial set-up. If only one segment is selected in the memory partition menu, the repeat factors may range from 1 through 65535. Preset value for the repeat multiplier is 1.

4. UTIL'S (Utilities) Menu

SEG01_MODIFY - The modification menu provides global operations on one or two segments. The usage of the utilities in this menu are discussed in paragraph 3-23-5. There are six built-in utilities: copy (0), Clear (1), Fill (2), Offset (3), Delete (4), AM (5), and Combine (6). DCL and preset select the Copy utility.

3-3-3-3. Arbitrary Wave Parameters Menus

1. CLOCK Menu

SAMPLE_RATE - The arbitrary wave is made of digital points which are equally spaced on the horizontal scale. The "spacing" between the points are defined as sampling rate or clock rate and has dimensions of sps (samples per second). The sampling rate, divided by the number of points, determine the repetition rate of the arbitrary waveform. The sampling rate may be programmed within the range of 10.00msps to 50.00Msps. Preset value is set to 10.00Msps.

WAVE_FREQ - The arbitrary wave frequency parameter is provided for those operators who do not wish to constantly compute this value from the sampling rate and the number of point. The wave frequency depends on many parameters: The sampling rate, the wavelength, and the number of times that the wave is repeated by the sequencer. However, the wave frequency interacts with the sampling rate only. When changing this parameter, the sampling rate and the wave_period parameters are automatically adjusted to the new value of wave frequency. Preset value is set to 305.3Hz (10.00Msps divided by 32767 point).

WAVE_PERIOD - The arbitrary wave period parameter is the reciprocal value of the wave frequency. It is provided for those operators who do not wish to constantly compute this value from the sampling rate and the number of point. The wave period depends on many parameters: The sampling rate, the wavelength, and the of times that the wave is repeated by the sequencer. When changing this parameter, the sampling rate and the wave frequency parameters are automatically adjusted to the new value of wave period. Preset value is set to 3.276ms (10.00Msps multiplied by 32767 point).

2. DATA Menu

SEGdd_ADD - The segment_address provides the "X" coordinate, in points, on an arbitrary waveform which is located in the selected segment. "dd" represents the selected segment number. There is only one address for each point on the arbitrary waveform. Each address may have a different "Y" coordinate; depending on the shape of the waveform. When the segment address is modified, the corresponding data is displayed on the second line. When the arbitrary waveform is displayed on an oscilloscope, the selected address may be intensified by the marker output signal; using the z-axis input on the oscilloscope. Depending on the size of the selected segment, the address may vary from address 1 to address 32767. Preset value is set to address 00000.

SEGdd_DAT - The segment_data provides the "Y" coordinate, in points, at a specific segment_address. "dd" represents the selected segment number. When the segment address is modified, the corresponding data is displayed on this line. The data may then

Table 3-1. Default State After Software Reset

FUNCTION	DESCRIPTION	DEFAULT STATE
General Parameters Menus		
MAIN		
FREQ	Frequency	1.000KHz
AMPL	Amplitude	1.00V
OFFS	Offset	+000mV
TRIG		
TRIG_LEV	Trigger level	+1.6V
TRIG_SLOP	Trigger slope	Positive going edge
TRIG_PHAS	Trigger phase	+00°
TRIG_COUN	Trigger counts (Burst)	00001
INT_PER	Internal period	1.00s
SWEEP		
LIN_SWEEP	Linear sweep mode	On
SWEEP_DIR	Sweep direction	Up
START	Sweep start frequency	1.000KHz
STOP	Sweep stop frequency	9.999KHz
TIME	Sweep time	1.00s
MARK	Sweep marker frequency	5.000KHz
PHASE		
EXT_REF/	External reference division ratio	/00001
PHAS_OFFS	Phase lock offset	000°
Arbitrary Wave Parameters Menus		
CLOCK		
SAMPLE_RATE	Sampling rate	10.00Msps
WAVE_FREQ	Wave frequency	305.2Hz
WAVE_PERIOD	Wave period	3.277ms
SYNC		
SYNC_ON	Sync location	SEG01
SYNC_ADD	Sync address	00001
Z_LEVEL	Z-axis level	−0.10V
FILTER		
ARB_FILTER	Arbitrary analog filter	Off (no filter)
Arbitrary Memory Management Menus		
SET-UP		
MEM_PART	Memory partitions	01
SEG01 =	Segment size	32768

Table 3-1. Default States After Software Reset (continued).

FUNCTION	DESCRIPTION	DEFAULT STATE
LOAD		
SEG01_SOURCE	Load source to segment 01	From digitizer
SEQU		
SEQ_STEP	Number of sequencer steps	01
UTIL'S		
SEG01_MODIFY	Modification utility	Copy
Digitizer Menus		
HORI		
RATE	Digitizing sampling rate	100.0Ksps
VERT		
FULL_SCALE	Digitizer full scale window	±5V
TRIG		
TRIG_SRC	Trigger source	INT
TRIG_LEV	Trigger level	+0.0V
TRIG_SLOP	Trigger slope	Positive going edge
TRIG_DEL	Trigger delay	None
General Status		
DISPLAY	Main menu parameters	FREQ, AMPL
OPERATING MODE	Operating mode selection	Normal function generator
STATE	GPIB status	Local state
TRIG MODES	VCO stimulant	Internal, Continuous Mode
OUTPUT	Output waveform	Sinewave
ST-BY	Output stand-by mode	Off

be manually edited and modified by the dial or by the AUTO LINE push-buttons.

3. SYNC (Synchronization) Menu

SYNC_ON SEGdd - This parameter defines the segment number of which the SYNC output pulse will appear on. It is necessary to define the segment number because of the sequencer circuit. The sequencer may be programmed to output a multiple of different segments, in non-sequencial order. The user may then select on which segment to place the SYNC output signal. The SYNC output defaults to segment 1 on preset.

SYNC_ADD - Defines an address within the selected segment of which the SYNC output pulse will appear. Preset value for the SYNC address is 0.

Z_LEVEL - Determines the voltage level at the rear panel Z-OUT connector. This output is used for driving z-axis inputs on oscilloscopes or monitors. The output level is programmable within the range of −0.10V to −5.00V. Preset value is set to −0.10V.

4. FILTER Menu

ARB_FILTER - Model 85 provides three-range low-pass filters which can be used to smooth the digital steps of the arbitrary waveform. Filter options

are: None (0), 5MHz (1), 500KHz (2), and 50KHz (3). The arbitrary filter is made of a 2-pole Bessel-type analog filter. The arbitrary filter defaults to no filter (0) on preset.

3-3-4. DIGITIZER MENUS

1. HORI (Horizontal) Menu

RATE - The rate parameter defines the digitizing sampling-rate. The model 85 takes samples from the digitizer input at the rate determined by this parameter. The sampling rate is continuously programmable from 10.00msps to 300.0Ksps. Sampling-rate preset value is 100.0Ksps. sps is samples per second.

2. VERT (Vertical) Menu

FULL_SCALE - This parameter defines the vertical window of which the captured signal must fit into. There are three vertical full-scale windows: ±1V, ±2V, and ±5V. Preset full-scale window is set to ±5V.

3. TRIG (Trigger) Menu

TRIG_SRC - One must tell the instrument when to start digitizing so that only the required portion of the input signal is captured. Therefore, the digitizer will sample the input signal when a ready flag is sensed. There are a number of trigger sources that will trigger the digitizer: Internal (0) - at the Digitizer input, External (1) - at the Trigger input, and Manual (2) - triggered by front panel push-button.

TRIG_LEV - The Trigger Level parameter sets threshold level that will trigger the digitizer. This level is set for both internal and external sources. The trigger level parameter may be programmed within the range of −9.9V to +9.9V. Preset value is set to 0.0V.

TRIG_SLOP - The Trigger Slope parameter selects the edge sensitivity that will trigger the digitizer. The operator may select to commence digitizing on the rising edge (0), or on the falling edge (1) of the signal. Preset value is set to trigger on the rising edge (0).

TRIG_DEL - The Trigger Delay menu provides selection of delay options on the digitized signal. Available delay options are: None (0), Pre-Trigger (1), and Post-Trigger (2). The use of trigger delays is discussed in paragraph 3-23-8.

PRE_TRIG - The Pre-Trigger parameter defines the portion of the signal that will be captured by the digitizer - before the trigger flag has been sensed. Pre-trigger limits are from address 0 to address 32765. Preset value is set to 0 (no delay).

POST_TRIG - The Post-Trigger parameter defines the portion of the signal that will be captured by the digitizer - after the trigger flag has been sensed. Post-trigger limits are from address 0 to address 65531. Preset value is set to 0 (no delay)

3-3-5. Parameter Select/Edit Section

CURSOR/MENU CONTROL - There are four push-buttons that control the position of the cursor within each menu. These buttons are marked with arrows; each arrow points in different direction. The push-buttons which are marked with the up and down arrows are used for scrolling through the various parameters within a specific menu. The push-buttons which are marked with the left and right arrows are used for placing the cursor on the data which has to be modified.

DIAL - The Dial is a mechanical rotary-encoder that simulates a digital potentiometer. It is used for editing the displayed parameter. The dial may rotate clockwise to increment reading or counterclockwise to decrement reading.

EXE - This push-button is used for executing a specific function which requires complete operators' attention. It is normally used in conjunction with front panel settings of the arbitrary parameters that modify front panel settings permanently.

ON/OFF - This push-button is used for terminating front panel operations before the [EXE] push-button has been pressed.

3-3-6. Trigger Modes Section

There is only one push-buttons in the TRIG MODES section. Selection of one of the trigger modes is done by pressing this button. The selected mode is indicated by an LED. Model 85 may be triggered from either one of the following sources:

1. External signal which may be applied to the TRIG IN connector
2. An internal - asynchronous trigger generator
3. GPIB commands (like GET or *TRG)
4. Front panel [TRIG] push-button

The [TRIG] trigger is active when the instrument set to operate in external trigger mode. This push-button when depressed serves as a replacement for an external trigger source.

Tabel 3-2. Front Panel Parameter Entry Limits

PARAMETER	LOW LIMIT	HIGH LIMIT	REMARKS
FREQ	10.00mHz	50.00MHz	
AMPL	10.0mV	16.0V	Into 50Ω
OFFS	0.0mV	±795mV	Within a ±800mV level window
OFFS	0mV	±7.95V	Within a ±8.00V level window
TRIG_LEV	0.0V	±9.9V	
TRIG_PHAS	0°	±90°	
TRIG_COUN	1	65535	
TRIG_PER	999s	20μs	
START	10.00mHz	50.00MHz	
STOP (log sweep stop)	10.00mHz	50.00MHz	
STOP (lin sweep stop)	10 display counts	5000 display counts	
TIME	10ms	999s	
MARK (log marker freq	10.00mHz	50.00MHz	
MARK (lin marker freq)	10 display counts	9999 display counts	
EXT_REF	/1	65535	
PHAS_OFFS	0°	±180°	
SAMPLE_RATE	10.00msps	50.00Msps	
SYNC_ADD	1	32767	
Z_LEVEL	−0.10V	−5.00V	
ARB_FILTER	50KHz	5MHz	50KHz, 500KHz, and 5MHz
DIGITIZER RATE	10.00msps	300.0Ksps	
DIGITIZER FULL_SCALE	±5V	±10V	
DIGITIZER TRIG_LVL	0.0V	±9.9V	
DIGITIZER PRE_TRIG_DEL	0	32765	
DIGITIZER POST_TRIG_DEL	0	65535	
*SAV (store)	0	9	
*RCL (recall)	0	9	
ADR (GPIB address)	00	31	

3-3-7. Output Section

There are two push-buttons in the OUTPUT group. These buttons are used for selecting an output waveform for the output connector. The selected function is indicated by an LED.

3-3-8. Auto Line

There are two push-buttons in the Auto Line group. These buttons are used to select first and second points, on the arbitrary waveform. When the second point is selected, a straight line is automatically generated between these two points.

3-3-9. Arbitrary Memory Back-up/Recall

The Back-up push-button is used for saving the arbitrary waveforms along with the arbitrary parameters. It is used like a back-up diskette on a computer that contains the files and the system commands. The Recall Back-up push-button restores front panel parameters for the arbitrary section only.

3-4. CONNECTORS

The connectors are used for connecting the Model 85 to the unit under test, to a control device, and to an external triggering stimulant.

1. DIGITIZER INPUT - An external signal applied to this connector will be digitized by the built-in digitizer.

2. TRIG IN - The TRIG IN connector is used for applying an external triggering source to the function generator. The same connector is used in conjunction with the phase lock operating mode where the reference signal is applied to this connector.

3. SYNC OUT - The SYNC OUT connector outputs fixed amplitude pulses from a 50Ω source. The leading edge of the SYNC output is synchronous with the leading edge at the main output connector.

4. OUTPUT - The OUTPUT connector is used as the main output for the function generator. Output is driven from a 50Ω source. Special care should be taken when these outputs are connected to the device under test because these outputs are capable of delivering up to 32Vp-p.

3-5. DISPLAY AND INDICATORS

1. DISPLAY - The function of the numeric display is to indicate the value of the various parameters. The 85 is using of a 2-line, 16-character LCD display. The display is back-lit to enhance the LCD readout. The display is also used to indicate other information such as messages, errors, help, machine status, and more.

2. INDICATORS - 29 indicators are located on the front panel. These indicators are used as pointers to a selected menu, operating modes, trigger modes etc.

3-6. REAR PANEL CONNECTORS AND SWITCHES

1. AC RECEPTACLE - Power is applied through the supplied power cord to the 3-terminal AC receptacle. Note that the selected ac mains voltage is marked on the line voltage selector switch.

2. LINE SWITCH - The LINE VOLTAGE SELECTOR switch selects one of the primary voltage which are marked on both sides of the switch.

3. LINE FUSE - The line fuse provides protection for the AC power line input. For information on replacing this fuse, refer to Section 5.

4. IEEE-488 CONNECTOR - This connector is used for connecting the instrument to the IEEE-488 bus.

5. SWEEP OUT CONNECTOR - This connector is used for connecting the instrument the X input on the oscilloscope. Its output level is either fixed - in linear sweep mode, or proportional to the sweep time per decade - in logarithmic sweep mode.

6. Z/MARK OUT CONNECTOR - This connector is used for connecting the function generator to the Z input on the oscilloscope. This output is active with the sweep or the arbitrary modes.

7. MODUL'N INPUT - This connector is used for connecting the modulating signal to the function generator. This input accepts frequency modulation, amplitude modulation, and controls the oscillations of the main frequency with an external voltage.

3-7. POWER-UP PROCEDURE

The basic procedure of powering up the Model 85 is described below.

1. Connect the female end of the power cord to the AC mains receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

WARNING

Be sure the power line voltage agrees with the indicated value on the rear panel of the instrument. Failure to heed this warning may result in instrument damage.

The instrument is equipped with a 3-wire power cord designed to be used with grounded outlets. When the proper connections are made, the instrument chassis is connected to the power line ground. **Failure to use a properly grounded outlet may result in personal shock hazard.**

2. Turn on the mains power by pressing and releasing the POWER switch on the front panel.

3. The instrument then begins operation by performing a display and indicator test which takes approximately one second. All front panel indicators illuminate.

4. After all the indicators are tested, the instrument performs ROM and RAM tests. Successful execution of these tests is followed by a one second read-out of the installed software revision, similar to the example below:

Software Rev 1.0
last update 8/92

5. The model 85 then checks which of its options is installed and displays a message when it recognizes an option. The installed option message will look like the following:

GPIB option
installed

6. If the instrument detects that the GPIB option is installed and displays the above message, the instrument proceeds with displaying its GPIB primary address. The GPIB address is set by front panel programming and is stored in the non-volatile memory. For example, with the generator programmed to address 19, the display shows:

GPIB address
19

7. Following these display messages, the instrument commences its normal operating mode and generates waveforms. Note that the instrument is equipped with a non-volatile memory. This memory automatically monitors front panel traffic and retains its latest set-up for events such as accidental power loss. In case of power loss the instrument resumes operation with its previously programmed front panel set-up.

NOTE

One who does not wish to observe the power-up procedure every time that the generator is turned on, can easily remove the sequence of displayed messages. Depressing [2nd] and then [Parameter Select ⇑] in sequence writes a special code to the non-volatile memory. The next time the generator will be powered-up, the instrument will skip the power-up procedure and will immediately commence with displaying the front panel set-up. Repeating the sequence of [2nd] and [Parameter Select ⇑] restores normal power up procedure. Note that there are no front panel markings that indicate power-up sequence removal. Therefore, unless the instrument is being used by one person only, and to remove confusion, it is recommended that power-up sequence remains unchanged.

3-8. SOFTWARE RESET

An operator who is not yet fully familiar with front panel operation of the function generator, may find himself locked into a "dead-end" situation where nothing operates the way it should. The fastest way of restoring the generator to a known state is by resetting its software. This may be done by pressing the [2nd] push-button and then pressing the [DCL] push-button (second function to the [TRIG] push-button). The instrument then resets to its factory selected defaults. Table 3-1 summarizes these defaults.

3-8-1. Parameter Preset

As discussed in paragraph 3-5, software reset restores all front panel parameters to their factory selected values. It may, however, be required to preset one or two parameters and leave the rest intact. In that case the instrument provides additional capabilities with its [P.SET] (preset) function. Pressing [2nd] and [P.SET] push-buttons in a sequence modifies the displayed parameter, at the cursor position, to its default value. Default values are summarized in Table 3-1.

NOTE

Software reset has no effect on the stored front panel set-ups. Software reset also has no effect on the programmed GPIB address.

3-9. DISPLAY MESSAGES

Model 85 has several display messages pertaining to its operation. The generator also displays an error indication when a front panel programming error is detected. These messages and error indications are discussed in the following. Note that the instrument has a number of additional display messages associated with IEEE-488.2 programming. These messages are discussed in section 4 of this manual.

3-10. DETECTING PROGRAMMING ERRORS

Model 85 is a product of many years of experience and complete understanding of human engineering requirements. During its design stage, a great deal of time has been devoted to simplify front panel programming procedures in order to minimize the potential of programming errors. It is impossible however for an inexperienced operator to completely avoid programming errors. For such cases, the function generator employs a built-in error detection mechanism which warns against programming errors.

There are several error indications that may occur due to incorrect front panel programming procedures. The indications are either visible (error messages) or audible (beeping sound). The audible alarm sounds while attempting an incorrect front-panel programming sequence. For instance, an attempt to exceed parameter limits which are listed in Table 3-2, is a cause for such an alarm. The alarm sounds as long as the conditions remain false. Other error conditions which may cause an audible alarm are discussed in different parts of this manual.

Front panel programming errors are normally indicated by an audible alarm. GPIB errors are detected automatically and are screened for a service request poll. These indications are described in the following paragraphs.

3-11. FRONT PANEL ERROR INDICATION

In general, whenever a front panel or GPIB programming attempts to place the 85 in an error condition, the Model 85 responds by front panel error indication or by addressing the IEEE-488.2 service request register.

Errors are categorized in four main groups:

1. General errors
2. Limit errors
3. IEEE errors
4. Auto-Calibration errors

3-11-1. General Errors

Errors in this group are caused by improper usage of the instrument. Such errors occur while attempting to place the instrument in an illegal mode. For example, depressing simultaneously two push-buttons (except [1st MENU]) has no valid definition or by depressing the MANUAL push-button while the instrument is in its continuous operating mode. In such cases, the instrument sounds an audible alarm, ignores this error, and continues with its normal operation.

3-11-2. Limit Errors

Errors in this group are caused by an attempt to program values outside the legal limits of the instrument. The instrument automatically rejects any attempt to program such parameters, sounds an audible alarm, and then resumes normal operation. Table 3-2 summarizes all front panel entry limits.

3-11-3. IEEE-488.2 Errors

In general, whenever a GPIB programming attempts to put the model 85 into an error condition, the function generator responds in two ways. First by displaying a front panel message and than, if programmed so, by raising an SRQ flag in its Status Byte Register. Using the serial poll command, the controller may then address the generator and request its status byte.

The generator incorporates a number of display messages which are associated with errors involving GPIB interface programming. These messages are discussed in detail in Section 4 of this manual.

There is one message however, which should be explained at this point because it may interfere with front panel operation. A remote enable or a device dependent command, sent to the instrument through the bus, turns the RMT (remote) light on. In this case, all front panel push-buttons except [LOCAL] are disabled. Pressing one of these push-buttons causes the function generator to respond with the following message:

press LOCAL to
remove from RMT!

This message indicates that the instrument expects that the [LOCAL] push-button be first depressed otherwise front panel operations are ignored. After the [LOCAL] button is depressed, the RMT light turns off and the instrument is ready to accept additional front panel programming sequences.

3-11-4. Auto-Calibration Errors

Model 85 provides an auto-calibration function which may be used, anytime, by the operator. In the event that the calibration routine fails to successfully complete, the generator generates a failure list and starts displaying the calibration failure list.

3-12. SELECTING 2nd FUNCTIONS

A few front panel push-buttons were assigned a secondary function. These functions are marked below the button in yellow color and are accessible through the [2nd] push-button.

There are eleven front panel buttons which were assigned a secondary function. These functions are:

DCL	HELP
SAVE	RECALL
GPIB ADR	DIAL LOCK
P.SET	UNDO
AUTO-CAL	ST-BY
FAIL LIST	

The operation of these secondary functions is described later in this chapter. Pressing the [2nd] push-button generates the following display read-out:

2nd ?

The cursor under the question mark (?) appears blinking; indicating that the instrument is ready for a consequent press of another push-button which was assigned a secondary function. Depressing [2nd] once more cancels this function. Second functions: DCL, DIAL LOCK, P.SET, UNDO, and ST-BY functions are executed immediately; SAVE, RECALL, GPIB ADR, AUTO-CAL, and FAIL LIST will be executed only after depressing the [EXE] push-button.

3-13. AUTO-CALIBRATION

Model 85 provides an auto-calibration function that may be operated at any time, either from the front panel or through a GPIB command. Operating the auto-calibration is very simple and can be done by anyone; no special skills are required. Although this function can give the user relative confidence that the instrument is operational and within specification, it is still recommended that the function generator will be checked periodically by certified calibration laboratories. Suggested calibration period by certified calibration laboratories is given in Section 5 of this manual. The auto-calibration takes only few seconds to complete. It therefore could be used often without serious delay to its normal operation. However, the auto-calibration function should be performed when one or more of the following conditions occur:

1. After 30 minutes of warm-up time;
2. After 24 hours of last internal auto-calibration;
3. If ambient temperature changes by more than 5°C, and;
4. After replacing components or sub-assemblies.

To operate the auto-calibration function proceed with the following steps:

1. Depress the POWER switch once to turn power on, and leave the instrument on for at least 30 minutes until the internal circuits reach thermal equilibrium.

2. Depress [2nd] and then the [AUTO-CAL] push-buttons, and observe that the generator displays the following:

Calibrate ?
EXE = yes OFF = no

Depress [OFF] quit the auto-calibration sequence and return to normal operation. Depressing [EXE] initiates the calibration routine. The above display message is replaced by a sequence of messages that indicate the function which undergoes calibration.

Following successful execution of its internal calibration, the instrument displays a message indicating that the calibration process has been successful. Tee message looks like the following:

Calibration ok!
push any key

Depressing a key causes the instrument to resumes normal operation.

If self calibration fails, the generator proceeds with displaying a failure list. Recalling and terminating the failure list display is described in the succeeding paragraph. Analyzing and interpreting the failure list is described in Section 5.

3-14. REVIEWING THE AUTO-CALIBRATION FAILURE LIST

As discussed above, if the auto-calibration fails to successfully complete, the instrument automatically generates a failure list. The operator can review this list either immediately after the auto-calibration process or anytime later provided, however, that a subsequent calibration process did not remove one the previously generated errors.

If the auto-calibration completes without detecting a calibration error, no failure list is generated and the function generator resumes normal operation. If a calibration error is detected, the generator starts displaying a message as follows:

CAL FAILURE LIST
parameter d

Where parameter represents the parameter that has failed to calibrate itself and d represents the range that presents the problem. The auto-calibration failure list is also available as a GPIB failure status query.

To terminate this display message and to exit from the failure evaluation process depress any front panel push-button. To evaluate the complete failure list rotate the dial clockwise to go up with the list. The displayed parameter name and its associated digit indicates where the instrument has failed to calibrate itself.

To recall the last saved failure list depress the [2nd] and the [FAIL LIST] push-buttons in sequence and observe that the instrument displays the message as described above. Commence with the evaluation using the same procedure as was described above.

3-15. SELECTING AND MODIFYING PARAMETERS

3-15-1. The Menu Concept

An instrument, as complex as model 85, would have been extremely difficult to program if the parameters would not be grouped and placed in menus. The menu concept cuts down the number of buttons which are necessary to access parameters and simplifies understanding of front panel programming.

The various parameters which are required to program Model 85 are grouped in four logical menus:

General parameters, Arbitrary wave parameters, Arbitrary memory management, and Digitizer parameters. The general-parameters menus control the operation of the function generator; they also set the required values for the built-in analog functions. The arbitrary-memory-management menus control the memory partition, segment sizes, segments' sequence, load source, and some built-in software utilities. The arbitrary-wave-parameters menus control the sampling rates, filtering option, and set the values for the SYNC and marker outputs.

A specific menu is selected and displayed on the front panel readout when the light next to the menu name illuminates. Menus may have a minimum of one line and may have as many as 10 lines; each line representing a different parameter. The menus are selected by pressing one of three buttons in the Edit Menus, or the button in the Digitizer field. One may then scroll through the various parameters within the selected menu by pressing the [⇑] or [⇓] arrows in the Parameter Select/Edit section. The [⇐] and [⇒] push-buttons control the cursor position on the displayed value.

The right character position on any displayed parameter is always reserved for an indication if there are additional parameters above or below the displayed parameter. This indication is done with an arrow; pointing up when more parameters are available above, or an arrow pointing down when more parameters are available below. It is possible for both arrows to show; indicating that parameters are available below and above the displayed parameter.

When both [⇑] and [⇓] keys in the Parameter Select/Edit section have been pressed simultaneously, the pointer jumps to the top parameter. Pressing [2nd] and [P.SET] sequentially, forces the displayed parameter, that has the cursor placed on it, to its default value. The dial may be locked to prevent accidental change of parameters by pressing [2nd] and [DIAL LOCK] sequentially.

3-15-2. The Displayed Readout Concept

Any parameter which is displayed on the front panel has two or three parts: Header, Data, and most times Suffix (in most cases). For example, trigger level parameter is displayed as follows: TRIG_LEV +1.6V.

The **Header** describes the function of the parameter, for example, FREQ, AMPL, and SAMPLE_RATE. The header, in most cases is not spelled in-full, but abbreviated in such a way that will make sense to the operator. The headers follow the SCPI (Standard Commands for Programmable Instruments) convention, which specifies the use of such abbreviation. Exactly the same headers are used for GPIB programming; making it easier for the GPIB programmer, who does not need to study reference tables from the manual.

The **Data** is separated from the header by space(s) and may contain integer numbers, floating decimal point, and a leading plus or minus sign. The data represents the value for the displayed header. Each header has different limits for its associated data. These limits are given in Table 3-2.

The **Suffix** associates units and multipliers that modify how the data is interpreted by the device. Some headers, like TRIG_COUN and SWEEP_DIR, do no require the presence of the suffix.

3-15-3. The Cursor and Dial Concept

The cursor, as discussed above, can be move within the menus from line to line and from a data character to a neighboring data character, using the Parameter Select/Edit push-buttons. The dial modifies characters on the cursor location. For instance, With an offset reading of +123mV, if the cursor is placed on 3, this digit will increment or decrement; depending on the direction one rotates the dial. If the cursor is placed on the sign, the dial, when rotated, will modify the sign only. Placing the cursor on a suffix and then rotating the dial, increments or decrements the range.

3-15-4. Modifying a Parameter

There are various parameters, such as frequency, amplitude, offset, sampling rate, and others which control the shape of the waveform at the output connector.

Modification of a specific parameter is simply done by selecting the required parameter as discussed in paragraph 3-15-1, placing the cursor on the required digit for modification, and then rotating the dial until the correct value is displayed. Some modifications cause immediate change at the output connector. Some modification require that [EXE] button be first pressed before output parameters will change. The various parameters which can be displayed and modified are listed in Table 3-2

3-15-4-1. Parameter Limits

In general, parameters were assigned definite boundaries. The instrument was design in such a way

that front panel programming, under no circumstances, may lead to an error situation by exceeding the specified limits. GPIB parameter programming errors are discussed in section 4. Front panel programming permits modification of parameters within the limits which are given in Table 3-2.

3-16. SELECTING AN OPERATING MODE

Model 85 may operate in normal function generator mode, as a sweep generator (linear or logarithmic), The generator may be modulated by an external signal, and may phase lock to a stable reference source. Selecting one of the operating modes is done by depressing one of the OPERATING MODE [⇑ or ⇓] push-buttons until the light next to the desired mode illuminates. When all light are off, the instrument is placed in normal operating mode.

Description of the various modes which can be used in Model 85 is given in the following.

3-16-1. Normal Function Generator Operating Mode

Function generator operating mode is the normal operating conditions where the output waveform is symmetrical about its horizontal and vertical axis. The generator is placed in its normal operating mode when all light are off. Triggered operation may operate in conjunction with the normal function generator operating mode.

3-16-2. Linear/Logarithmic Sweep Operating Mode

Placing the model 85 in linear or logarithmic sweep operating mode transforms the instrument into an independent sweep generator. Selecting the sweep operating modes is done by depressing one of the Operating Mode [⇑ or ⇓] push-buttons until the light next to SWEEP illuminates. Sweep steps (linear or logarithmic), sweep direction, and other sweep parameters may be programmed in the Sweep menu. The various sweep modes may operate in conjunction with the external trigger mode.

3-16-3. Modulation Operating Mode

Placing the instrument in this operating mode is done by depressing one of the Operating Mode [⇑ or ⇓] push-buttons until the light next to MODUL'N illuminates. The modulating signal is applied to the rear panel MODUL'N INPUT BNC connector. Selecting one of the built-in modulation options is done in the MAIN menu. Model 85 provides three modulation modes: AM, FM, and VCO. The various modulation mode are discussed in the following.

3-16-3-1. Frequency Modulation (FM) Mode

The generator, when placed in this mode, operates as a free running voltage controlled oscillator. The applied sinewave at the control INPUT connector determines modulation characteristics.

To frequency modulate the instrument first select the FM mode, and then apply the modulating signal to the rear panel MODUL'N INPUT connector. Observe external signal limits to avoid damage to the input circuit.

3-16-3-2. Amplitude Modulation (AM) Mode

The instrument, when placed in this mode, releases its amplitude control to an external control. A signal with an appropriate characteristics modulates the amplitude at the main output connector. Any of the available output waveforms may be modulated by the AM input modulating signal.

To amplitude modulate the generator first select the AM mode, and then apply the modulating signal to the front panel MODUL'N INPUT connector. Frequency and amplitude limits of the modulating signal should be observed to avoid damage to the input circuit.

3-16-3-3. Voltage Controlled Oscillator (VCO) Mode

Placing the function generator in VCO (voltage controlled oscillator) operating mode removes the frequency control from its output connector. The frequency of the selected waveform is then proportional to an amplitude level of a signal which may be applied to the MODUL'N INPUT connector.

To operate the generator as a voltage controlled amplifier first select the VCO mode, then apply the control voltage to the rear panel connector. Input limits should be observed to avoid damage to the input circuit.

3-16-4. Phase Locking Generator Operating Mode

Model 85 employs an automatic locking circuit which enables phase and frequency locking to an external reference. Model 85 locks on the external reference signal regardless of its programmed frequency setting.

After the generator has locked on the signal, the user may generate a phase offset between the external signal and the signal at the output connector. Offset range is ±180°. The generator is placed in its phase locking operating mode when the light next to PLL blinks. The light will blink as long as a signal is not applied to the TRIG IN. The light will stop blinking when the generator locks to the external source. The phase locking operating mode can not be operated in conjunction with the triggered modes.

Once locked to an external reference, the frequency at the output connector assumes the same stability and accuracy as of the reference signal. The output of model 85 may be then divided by integer numbers from 1 through 65535. This feature turns the generator into an accurate frequency divider. The accuracy, stability, and phase relation is still retained - in-full throughout the dividing range.

It s also possible to introduce a phase offset between the reference signal and model 85 output signal. Phase offset may be programmed from −180 to +180 degrees. External frequency division ration and phase offset parameters are available in the PHASE menu.

3-16-4-1. Using Model 85 as a Frequency Counter

Model 85 employs a built-in frequency counter circuit which is used in different parts of the instrument for various purposes. This internal counter is utilized when the instrument is placed in its PLL operating mode for automatic detection of the frequency of the external reference. The frequency counter reading is made available to the user and can measure external frequencies from 10Hz to over 60MHz. Frequency reading is given with fixed resolution of 4 digits. Decimal point and exponent are displayed automatically.

To use Model 85 as a frequency counter place the mode 85 in PLL mode and display the FREQ parameter in the MAIN menu. Make sure that the EXT_REF_/ parameter is programmed to a dividing ratio of 1 (use the procedure given in paragraph 3-15 to modify the parameters). At first, the instrument displays the programmed frequency value. When locked, the light next to PLL stops blinking and the display reading converts to read the external frequency. When external frequency is read, the decimal point blinks at the rate of the internal gate time.

3-17. SELECTING AN OUTPUT WAVEFORM

Selecting one of the available output waveforms is done by depressing one of the two push-buttons in the OUTPUT section until the light next to the required waveform illuminates. Model 85 makes available six different waveforms through the OUTPUT connector. These waveforms are:

Sine Wave	**Positive Square Wave**
Triangle	**Negative Square Wave**
Squar Wave	**Arbitrary Wave**

3-18. DISABLING THE OUTPUT

The Model 85 features a stand-by mode which disconnects the signal from the output connectors. The stand-by function is especially useful in automatic test systems where the output is constantly connected to the device under test and where modification of waveform parameters may endanger this device.

To place the instrument in its stand-by mode depress in sequence the [2nd] and the [ST-BY] push-buttons. The ST-BY light illuminates; indicating that the output signal is disconnected from the output connector.

To resume normal operation simply depress one of the push-button in the OUTPUT section. The ST-BY light turns off; indicating that the output signal in now connected to the output connector.

3-19. TRIGGERING THE FUNCTION GENERATOR

Model 85 when set to one of its trigger modes accepts stimulation from a variety of sources. The Operator has the option of selecting either an external source, an internal source, or a manual source. Each triggering method is used in a different way and for different applications. The triggering options are described in the following.

3-19-1. Triggering The Function Generator With An External Stimulant

When no light in the TRIG MODES section illuminates, the function generator operates in its normal continuous mode. Selecting an external triggering mode is simply a matter of depressing the push-button in the TRIG MODES section until the light next to E.TRIG illuminates.

The Model 85 triggers either on the leading edge or the trailing edge of the applied external signal. Each transition at the TRIG IN connector generates

a single waveform at the OUTPUT connector. The instrument can also generate more than one cycle of its output waveform by changing the counted triggers parameter to the required number of cycles. The various parameters for the trigger mode are available in the TRIG menu. The parameters which can be displayed and modified are: Trigger level, trigger slope, start phase (for sine and triangle only), counted triggers (burst), and the period of the internal trigger generator.

To trigger the generator from an external source proceed as follows:

1. Select the required output waveform and set up the parameters to the required characteristics.

2. Modify TRIG_LEV (trigger level) parameter to the required thrash-hold level.

3. Modify TRIG_SLOP (trigger slope) parameter to the required edge sensitivity.

4. If a different start phase is required (to generate haversines, for instance) modify TRIG_PHAS (trigger phase) parameter to the required angle.

5. Select the required number of output cycles (burst) with the TRIG_COUN (trigger count) parameter.

6. Depress the TRIG MODES push-button until the light next to E.TRIG illuminates.

7. Connect a BNC cable from the external stimulant to the front panel TRIG IN connector. Make sure to observe external signal limits to avoid damage to the input circuit.

8. When done with the triggered operation remove the BNC cable from the input connector and select the normal continuous mode.

3-19-1-1. Gated Mode

When set to operate in gated mode, the first transition at the TRIG INPUT connector enables the generator output. The consecutive transition disables the generator output. First output waveform is synchronized with the first external transition. Last waveform is always completed.

NOTE

The TRIG IN connector is sensitive to dc levels. If this input is left open and the trigger level was set to a negative voltage, the generator may self gate.

To gate the generator from an external source proceed as follows:

1. Select the required output waveform and set up the parameters to the required characteristics.

2. Modify the required parameter as explained in paragraph 3-19-1-1.

3. Depress the TRIG MODES push-button until the light next to GATED illuminates.

5. Connect a BNC cable from the external stimulant to the front panel TRIG IN connector. Make sure to observe external signal limits to avoid damage to the input circuit.

6. When done with the gated operation remove the BNC cable from the input connector and select the normal continuous mode.

3-19-2. Triggering The Function Generator With An Internal Stimulant

When an external source is not available, the operator has the option of using the built-in trigger stimulant. The internal trigger generator is a free running generator, asynchronous to the main output generator, and with a programmable period. Signal applied to the TRIG IN connector will have no effect on the generator when it is placed in internal trigger mode. The internal trigger generator may be used in conjunction with the triggered and the counted triggers modes; it can not, however, be used in gated mode. Operating the internal trigger generator is described in the following.

3-19-2-1. Internal Triggered Mode

When set to operate in internal triggered mode, the output connector generates one waveform at programmable intervals. Note that the programmed internal period should not exceed one half of the output waveform duration otherwise an error will result. To trigger the generator from the internal trigger generator proceed as follows:

1. Select the required output waveform and set up the parameters to the required characteristics.

2. If a different start phase is required (to generate haversines, for instance) modify TRIG_PHAS (trigger phase) parameter to the required angle.

3. Select the required number of output cycles (burst) with the TRIG_COUN (trigger count) parameter.

4. Modify INT_PER (internal period) parameter to the required spacing.

5. Depress the TRIG MODES push-button until the light next to I.TRIG illuminates; indicating that the internal trigger stimulant is now active.

3-19-3. Triggering The Function Generator With A Manual Stimulant

The [TRIG] button simulates an external signal. If the generator is placed in GATED mode, an output signal

will be available as long as the [TRIG] push-button is depressed. When the generator is set to E.TRIG (external trigger) mode, each time the TRIG button is depressed a single output waveform is generated. When the Model 85 is set to generate counted triggers (burst), each time the [TRIG] push-button is depressed the output generates a train of counted waveforms at programmable intervals. The TRIG push-button has no effect in normal mode of operation or when the instrument is set to internal trigger mode.

3-20. USING THE OFFSET

The function generator employs two level windows; allowing amplitude and offset to be independently selected within these levels. When setting up the offset parameter, one must keep in mind that the offset is attenuated with the signal. The user has no control over the selected internal amplitude range. This may cause some confusion since, not knowing this fact, one may produce an offset error at an amplitude-offset combination that seems to be reasonable. It is therefore suggested to first set up the amplitude parameter and only then to set the required offset level. An attempt to modify the offset parameter beyond the capability of the instrument will generate an error indication. Offsets and amplitudes are independently selectable within the level windows given in Table 3-3.

3-21. USING FRONT PANEL SET-UPS

Setting-up all parameters in a versatile instrument such as the Model 85 takes some time. The set-up time is longer when a number of tests are performed and more than one set-up is required. The function generator incorporates a non-volatile memory that preserves stored information for a long time. The size of the non-volatile memory permits storage of up to 10 complete front panel set-ups. Front panel set-ups can be recalled one at a time. The generator also employs a special recall mode that permits automatic scrolling through the stored set-ups for sequential tests. The operator may select to scroll in an ascending or descending order. Description how to save and recall set-ups and how to use the recall mode is given in the following.

3-21-1. Saving Set-ups

First modify front panel parameters as necessary to perform the required test. When all parameters are programmed and verified for accuracy, proceed with storing this set-up as follows:

1. Depress the [2nd] and [SAVE] push-button in sequence and observe that the display is modified to indicate the following:

SAVE_SETUP x
push EXE to save

"x" indicates the number of the present storage cell. Numbers may range from 0 to 9. Depressing any other push-button removes the generator from the memory store mode and leaves front panel settings unchanged.

2. To program individual memory cells for a specific front panel set-up modify "x" using the dial until the desired memory number is displayed. Depressing [EXE] locks in the entire front panel set-up for later usage. The instrument then resumes normal operation.

3. Repeat the above procedure for as many set-ups that are required. Stored front panel set-ups are limited to 9.

3-21-2. Recalling Set-ups

The model 85 employs a non-volatile memory (RAM). The computer circuit continuously monitors front panel traffic and saves it in a special location within the RAM. This location is separated from the stored front panel set-ups. After turning AC MAINS off or in case of an accidental power failure, the generator updates front panel indicators with the last set-up before power shut-down. To recall a stored front panel set-up proceed as follows:

Level Window	Amplitude Range	Offset Range
±8.00V	100mV to 16.0V	0V to ±7.95V
±800mV	10mV to 99.9mV	0V to ±795mV

Tabel 3-3. Offset-Amplitude Programming Limits

1. Depress the [2nd] and [RECALL] push-button in sequence and observe that the display is modified to indicate the following:

RECALL_SETUP x
push EXE to rec

"x" indicates the number of the present storage cell. Numbers may range from 0 to 9. Depressing any other push-button removes the generator from the memory recall mode and leaves front panel settings unchanged.

2. Recalling a specific front panel set-up is done rotating the dial until the desired cell number is displayed. Depressing [EXE] updates front panel set-up with the parameters which were stored in the selected memory cell.

3. Repeat the above procedure for as many set-ups that are required. Recalled front panel set-ups are limited to 9.

3-22. CHANGING THE GPIB ADDRESS

GPIB address is modified using front panel programming. The GPIB address is stored in the non-volatile memory. Therefore, conventional address switches are not provided. Detailed instructions how to change the GPIB address are given in Section 4.

3-23. GENERATING ARBITRARY WAVEFORMS

3-23-1. Introduction

In general, whenever the ARB LED, at the OUTPUT section, is lit, the model 85 generates arbitrary waveforms at the output connector. The arbitrary waveform is stored in a digital form in special memory that has a fixed length of 32K words. When the instrument is programmed to output arbitrary waveforms, there is a special software routine which replays the digital information which is stored in this memory.

The arbitrary waveform is made of digital samples. Each sample has vertical resolution of 12 bits. It is therefore possible to generate arbitrary waveforms that have 32,767 samples; each sample is placed on the vertical axis with precision of 1/4096 (12 bits). Model 85 provides control over the length of the arbitrary waveform and over its vertical resolution.

The arbitrary waveform is replayed one sample at a time. The speed of which each sample is replayed is defined by the sampling rate parameter. Model 85 provides programmable sampling rates from 10msps (Milli Samples Per Secon) to 50 Msps. The arbitrary waveform may be sampled repeatedly from start to stop, or sampled once - on command. It is also possible to sample the waveform for a counted number of times using the trigger count control.

In cases where smaller wavelenghts are required. Model 85 makes it possible to divide the entire length to smaller segments and then to select which segment is sampled, how many times, and in what sequence.

Unlike the built-in standard waveforms, the required arbitrary waveforms are not always resident in the instrument's memory. The reason for not always keeping the complete library resident is because of the size limitation of the arbitrary memory. Some waveforms have small length of 1K words or less, but some require much more. In cases where the arbitrary waveform is not resident, the instrument provides drivers to several communication links of which the waveform may be loaded from.

The are a number of ways to load the arbitrary memory with the required waveform. The most common way is to generate the waveform on a computer and then to download it through some standard communication links like the GPIB or the RS232. It is also possible to capture a waveform using a DSO or another digitizing device and then to download it to the instrument. Model 85 has an extra capability with its built-in digitizer which, in most cases, eliminates the need for external devices to capture the required waveform.

Information on how to manage the arbitrary memory, how to load waveforms to the various memory segments, how to sequence segments, how to edit a resident memory, and other operating instructions are given in the following.

NOTE

Setting up the arbitrary memory and loading waveforms to this memory is sometimes a tedious task. It involves a lot of preparation and sometimes, capturing of a rare signal. Therefore, it is suggested that you first make yourself familiar with the following procedure. We can reassure you that it will save a lot of rework and memory re-sizing if it is done correctly.

3-23-2. Arbitrary Memory Managment

The arbitrary memory has a fixed lenght of 32,767 words. It is, however, not always necessary to utilize

the complete length of this memory. Therefore, model 85 permits partition of the arbitrary memory to smaller memory segments. It is possible to divide the memory from 1 to 99 memory segments and then to flexibly change the size of each segment from 2 to 32,767 horizontal points. Setting up the arbitrary memroy is discussed in the following.

3-23-2-1. Setting Up the Arbitrary Memory

As discussed above, the arbitrary memory may be divided into smaller segments. The memory may be partitioned to segments having equal or non-equal memory lengths. The instrument is shipped from the factory with its arbitrary memory set up to have 32,767 points in one segment (Segment 01). Use the following procedure to change the number of segments and their relative sizes in the arbitrary memory.

1. Press the push-button which is designated ARB MEM MANAGEMENT until the light next to Set-Up illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. The displayed header and data should look like the following:

MEM_PART 01/EXE
01 SEGs active [DOWN]

The cursor is placed under the data (01). The second line shows the number of active segments.

3. To change the memory partition rotate the dial until the required number of partitions is displayed, then press [EXE]. The instrument starts displaying a sequence of questions which are necessary for it to determine the characteristics of the divided segments. The first question is:

Equal segments?
EXE = yes OFF = no

This questions is asked for the instrument to determine if the new number of segments will have equal number of points. If the [EXE] push-button is pressed, the instrument will divide the memory into equal segments. If [OFF] is pressed, the first segment will retain its original size and the new segments will be added having size of 0 points. When either [EXE] or OFF have been pressed, the instrument changes the reading to the following:

Are you sure?
EXE = yes OFF = no

This question is more like a warning because changing the memory partition may alter the resident waveform to a distractive and irreversible condition. Pressing EXE changes the memory partition. Pressing OFF leaves the memory intact.

4. Assuming that memory partition table has been changed to two non-equal segments, press the [⇓] push-button in the Parameter Select/Edit section to access the second menu. The following menu is then displayed:

SEG01 32767 Pts
00000 Pts left

This reading indicates that the memory size of segment 01 is 32,767 points long.

5. To change the size to, let's say, 1024 point, use the push-buttons and rotate the dial until the number is displayed correctly. Press [EXE] to let the instrument know that it should accept the new memory size. You'll be asked the following question:

Change SEE Size?
EXE = yes OFF = no

If you press [EXE], the size which you have selected will lock-in permanently and the above reading will change as follows (the same question will be asked if you'll try to leave this menu without finalizing the process):

SEG01 01024 Pts
31743 Pts left

6. Move the cursor under SEG01 and change the segment to 02. Follow the same procedure as above to change the size of the second segment to have 2048 points. The final display reading should look like that:

SEG01 02048 Pts
29695 Pts left

NOTE

You may notice that from the above example there are 29,695 points which were left unattended. This is because it is not necessary to always use the entire length of the arbitrary memory. Model 85 has a sophisticated sequencing circuit which can use only the required portion out of the complete memory. Therefore, when setting-up the memory partition table, you may leave part of the memory for future use.

3-23-3. Loading Waveforms

Model 85 does not have many built-in digital waveforms. However, being a digital instrument, Model 85 makes it possible to load to its memory the required waveform, using one of the methods which will be discussed in the following. The LOAD menu should be displayed in order to select the required source.

1. Press the ARB MEM MANAGEMENT push-button until the light next to LOAD illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. The displayed header and data should look like the following:

SEG01_SOURCE 0
From digitizer

This reading indicates that segment 01 will be loaded with digital data from the built-in digitizer.

3. To select a different load source for this segment, rotate the dial. The other sources to load waveforms from are: from built-in standard waveforms, and from previously saved memory.

3-23-3-1. Loading Waveforms Using the Built-In Digitizer

Model 85 has a special digitizing input where external signals may be applied to and captured instantaneously. The built-in digitizer provides a powerful tool to capture signals without the need for auxiliary devices and without tedious maneuvers to transfer waveforms from one device to another; thereby, having the risk of loosing data and other characteristics of the signal.

The signal, at the input to the digitizer, is sampled at rates from 10msps for extremely slow signals to 300Ksps for fast signals. The trigger point may be programmed before or after the triggering event, without the risk of loosing data, by utilizing the post and pre trigger facilities. The instrument provides programmable parameters for the vertical capturing window and for the trigger options. To load waveforms using the built-in digitizer proceed with the following instructions:

1. Press the ARB MEM MANAGEMENT push-button until the light next to LOAD illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. The displayed header and data should look like the following:

SEG01_SOURCE 0
From digitizer

This reading indicates that segment 01 will be loaded with digital data from the built-in digitizer.

3. Press the digitizer push-button to display the HORI (horizontal) menu. The display will look as follows:

RATE 100.0Ksps
push EXE to arm

This reading indicates that the signal at the digitizer input will be sampled at the rate of 100Ksps. The second line indicates that you may now push the EXE key to arm the digitizer input. Do not execute this function yet because you still have other parameters to program. Place the cursor under the suffix and rotate the dial to change the rate to 10.00Ksps.

4. Press the digitizer push-button to display the VERT (vertical) menu. The display will look as follows:

FULL_SCALE +/-5V
push EXE to arm

This reading indicates that the signal at the digitizer input will have a capturing window of ±5 volts. There are three window ranges that are available in Model 85: ±1V, ±2V, and ±5V. Rotate the dial and select the required range. Again, the second line indicates that you may now push the EXE key to arm the digitizer input. Do not execute this function yet because you still have trigger parameters to program.

5. Press the digitizer push-button to display the TRIG (trigger) menu. The display will look as follows:

TRIG_SRC 0 INT
TRIG_LEV +0.0V

This first line indicates the source which will cause the digitizer input to arm itself. The instrument will arm on the signal itself, when placed in INT mode; On external stimulant, when placed in EXT mode; or may be armed to digitize by pressing the [EXE] push-button. Rotate the dial to check the various options, but restore the trigger source to INT.

Press the Select/Edit push-buttons to move the cursor to the second line. The second line in this menu indicates the trigger level. Trigger level range is from -9.9V to +9.9V. When the digitizer is set to arm on internal source, the trigger level controls the digitizer input. When the digitizer is set to arm on external source, the programmed trigger level controls the TRIG IN input. Note that when selecting the MAN mode, the trigger level parameter is removed from this line because it has no effect.

6. Go one menu down and observe that the next menu is displayed as follows:

TRIG_LEV +0.0V
TRIG_SLOP 0 (|)

The first line is the same as discussed above; it has only move one menu up. The second line provides edge sensitivity control for the arming signal. Select between positive or negative going edges.

7. Go one menu down (use the [⇓] push-button) and observe that the next menu is displayed as follows:

TRIG_SLOP 0 (|)
TRIG_DEL 0 NONE

The first line is the same as discussed above; it has only move one menu up. The second line provides control over digital delay. Just like a digital oscilloscope, there are three options which are built into the instrument: 1) **NONE** - the instrument will capture and load to its memory digital information starting from the trigger event; 2) **PRE** - the instrument will capture digital information before the triggering event; and 3) **POST** - where the instrument will capture digital information after the triggering event. The pre/post trigger delays may be programmed using the next menu. Before you move to the next menu rotate the dial to select the pre-trigger mode.

8. Go one more menu down and observe that the next menu is displayed as follows:

TRIG_DEL 1 PRE
PRE_TRIG 00000

Move the cursor to the PRE_TRIG line and change the delay to the required interval.

9. The last menu is the execution line and will look as follows:

PRE_TRIG 00000
push EXE to arm

Push the [EXE] push-button and observe that the display reading changes as follows:

Preparing buffer
please wait!

and then:

Digitizer armed
apply signal

You may now apply the signal to be digitized to the Digitizer input connector. If the signal will agree with the various settings which you programmed, the digitizer will capture the signal and store it in the segment that was assigned for this purpose. You may unarm the digitizer by pressing [OFF].

If, for some reason or another, you forgot to assign a segment to be loaded from the digitizer input and you pressed [EXE], the instrument will display an error message as follows:

Error! select
memory segment

You must then follow the procedure as given above to assign the digitizer as a load source for one of the memory segments.

When the digitizer completes its digitizing process, the instrument displays the following message:

Digitizing complete
push any key !

With this message, the digitizing process is complete. Pressing any front panel push-button removes this message from the display and the instrument starts displaying normal menus and outputs the waveform at the output connector.

3-23-3-2. Loading Built-In Standard Waveforms

The are a few standard waveforms which are stored in special lookup tables. Use the following procedure to load these waveforms.

1. Press the ARB MEM MANAGEMENT push-button until the light next to LOAD illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. Rotate the dial and select the "From std waves" menu.

3. Go one menu down (use the [⇓] push-button) and observe that the second menu is displayed as follows:

SEG01_LOAD 0
Sine

You may rotate the dial to select from other waveforms like square, triangle and others. Leave sine as your preferred waveform.

4. Go one more menu down and observe that the third menu is displayed as follows:

Load Sine
H_RES 4096 Pts

The first line in this menu indicates the target of this menu. The second line represents the header - Horizontal Resolution, and the data for this header. The data which you program in this menu will tell

the instrument how many horizontal points will be used for the sinewave.

5. Change the resolution to 1024, because otherwise it will be too big or too small to fit in the size which you already selected segment 01.

6. Go one more menu down and observe that the forth menu is displayed as follows:

Load Sine
V_RES 4096 Pts

The maximum vertical resolution which can be used is 4096 points (12 bits). If the amplitude in the MAIN menu is set to 1.00V, using resolution of 4096 points will generate the full amplitude span of 1.00V. Using less resolution reduces the amplitude at the output connector proportionally. The ratio between the amplitude setting and the programmed vertical resolution is:

Amplitude (at output) = programmed amplitude x programmed vertical resolution / 4096.

For example, with programmed amplitude of 1.00V and programmed vertical resolution of 2048 points, the actual amplitude at the output connector will be 1.00 x 2048 / 4096 = 0.50V.

7. Go one more menu down and observe that the fifth menu is displayed as follows:

Load Sine
STA_ADD 00000

This menu indicates the address of which the sinewave will start loading. This option permits start address other than 1 so that more than one waves may be loaded in one memory segment. Leave start address as is for this example.

8. Go one more menu down and observe that the sixth menu is displayed as follows:

Load Sine
STA_PHASE 000(DEG)

Use this menu to change the start phase for the sine waveform. The start phase can be programmed in increments of 45 degrees.

9. The last menu executes the loading sequence. Observe the following display:

Load Sine
Push EXE to load

Pressing [EXE] causes the instrument to start loading the sine waveform. If data was previously loaded into segment 01, the instrument will ask you if you want to overwrite this data. Press [EXE] to overwrite, or OFF to leave this segment intact.

10. Use the same procedure as described above to load standard waveforms to other memory segments.

3-23-3-3. Loading Waveforms From the Backup Memory

One may save arbitrary waveforms in a back-up memory and recall them later. The waveforms are saved as segments. These segments contain the complete information which is necessary to restore it to its latest condition; including horizontal length, amplitude, and shape. Use the following procedure to recall waveforms from the saved memory.

1. Press the ARB MEM MANAGEMENT push-button until the light next to LOAD illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. Rotate the dial and select the "From saved mem" menu

3. Go one menu down (use the [DOWN] push-button) and observe that the second menu is displayed as follows:

Load from memory
RCL_SEG 01

This reading indicates that the instrument will recall segment number 01 from the back-up memory and will load it into the assigned segment.

4. Go one more menu down and observe that the third menu is displayed as follows:

Load from memory
Push EXE to load

Pressing [EXE] causes the instrument to start loading the waveform from its back-up memory onto segment 01.

3-23-3-4. Loading Waveforms Using the GPIB Interface

In general, there are no special preparations to be made before waveforms can be loaded from GPIB controllers. Model 85 is completely programmable, therefore, a computer can place it in listen mode, download all of the required parameters to set up Model 85, and download waveforms to a selected segment. Information on how to program Model 85 using the GPIB interface is given in Section 4 of this manual - IEEE-488 Programming.

3-23-4. Using the Sequencer

The sequencer circuit is another powerful function which is built into the Model 85. The sequencer circuit allows generation of arbitrary waveforms with flexible and multiple order of segments. For instance, one may program to generate the 2nd segment multiplied 5 times and then the 7th segment multiplied 2000 times and then the first segment multiplied 65535 times etc. There is almost no limit to the way that you can program the sequencer. This is also an extremely effective way to save internal memory by generating Giga words wavelength with only 32K or internal memory.

The sequencer can produce up to 99 steps; each segment may be repeated up to 65535 time in each step. If one utilizes the full capability of the sequencer, he may generate one waveform that will be 2.1259 x 10^{11} long. If one has enough time to wait for one waveform to complete, with a sampling rate of 50Msps, it may take as long as one hour and eighteen minutes to complete one cycle! Use the following procedure to write a sequence for the arbitrary generator.

1. Press the ARB MEM MANAGEMENT push-button until the light next to SEQU illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. Observe the display reading as follows:

SEQ_STEP 01/EXE
01 Steps active

The cursor is placed under the data (01). The second line shows the number of active steps.

3. To modify the active number of steps rotate the dial until the required number of steps is displayed. Press [EXE] to permanently change the number of steps. You'll be asked the following question:

Are you sure?
EXE=yes OFF=no

This question is more like a warning because changing the number of steps will have an immediate effect on the output waveform. Press [EXE] if this is what you want to do. Press [OFF] if you want to leave the number of steps intact.

4. Go one menu down (use the [DOWN] push-button) and observe that the second menu is displayed as follows:

STEP01 = SEG01
Repeat * 00000

This reading indicates that the first sequencer step will generate the waveform which is resident in segment number 01 00001 times. Use the Select/Edit push-buttons and the dial to select the segment and the number of times it will be repeated in each step.

3-23-5. Using the Built-In Utilities

There are a number of utilities which perform global operations on the arbitrary memory. The utilities make it possible to copy a waveform from one segment to another, to clear the contents of a segment, to fill a segment with a set of fixed data, and to offset the entire waveform by a known factor. The utilities menu also provide other functions like swap, delete, combine, and modulate.

1. To operate a utility press the ARB MEM MANAGEMENT push-button until the light next to UTIL'S illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. The following will be displayed:

SEG01_MODIFY 0
Copy

The first utility - copy is displayed. Rotate the dial and observe that the utility list. Follow the instructions on the display to perform the required utility function.

3-23-6. Changing the Sampling Rate

When programming function generators the output frequency is programmed in units of Hz and is directly proportional to the result at the output connector. Specifying the frequency of an arbitrary waveform is a little more complex since the waveform is made of digital samples. Depending on the number of samples, the number of segments, the sequence of the various segments, and on the sampling rate, the frequency may become a difficult task to compute.

The sampling rate is a parameter which defines the rate that each sample is clocked and placed at the output connector. The frequency is a derivative of the sampling rate and can be computed by dividing the sampling rate by the total number of samples.

Model 85 permits independent programming of either the sampling rate, the wave frequency or the wave period. While programming one parameter, the rest of the parameters are adjusted automatically to the correct value. This is extremely convenient since one does not have to compute frequencies and periods from the number of samples. The process

of changing the sampling rate is described in the following.

1. Press the ARB WAVE PARAMETERS push-button until the light next to CLOCK illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. The following will be displayed:

SAMPLE_RATE
10.00Msps

This display reading indicates the sampling rate at the output connector.

3. Scroll down to the next menu and observe that the display reading looks like the following:

WAVE_FREQ
305.2 Hz

The display reading indicates the frequency of the arbitrary waveform at the output connector.

4. Scroll down to the next menu and observe that the display reading looks like the following:

WAVE_PER
3.276 ms

The display reading indicates the period of the arbitrary waveform at the output connector.

3-23-7. Editing Waveforms Using the Auto Line

The autoline function is a front panel editing tool for simple modifications of arbitrary waveforms which are resident in a segments. The autoline operation generates a straight line between two end points which are designated as 1st Pt and 2nd Pt. The points in between the two end points are automatically computed and rearranged to form the line. The autoline operation requires an oscilloscope that has "Z" input for intensifying portions of the trace. When operating the autoline function, it is required to connect the Z-axis output to the oscilloscope and to adjust the Z_LEVEL parameter to get the required intensity of the markers. Proceed to operate the autoline function as follows:

NOTE

If you try to train yourself with the use of this function, it is suggested that your segment size be in the range of 100 to 1000 horizontal points and the sampling rate in the range of 10KHz to 1MHz. Otherwise, it will be very difficult to exercise the use of this function.

1. Set Model 85 to output an arbitrary waveform and connect the output to the oscilloscope input.

2. Modify SYNC_ADD and Z_LEVEL parameters in the SYNC menu to 00001 and -0.10V respectively. The procedure of adjusting these parameters is given in paragraph 3-23-8.

2. Connect the SYNC output to the oscilloscope sync input and make sure that the trace is stable and locked to the sync signal.

3. Connect the 85 Z-AXIS output to the oscilloscope input. Then adjust the sensitivity control on the oscilloscope to get the required brightness.

4. Press the ARB WAVE PARAMETERS push-button until the light next to DATA illuminates. Observe that the display reading looks as follows:

SEG01_ADD 00000
SEG01_DAT +dddd

The first line displays the address on segment number one where the marker is placed on. The second line displays the vertical data which corresponds the this address.

5. Use the push-buttons and the dial to change the pointer address to about mid-point on the waveform. Now you may already see an intensified marker on the oscilloscope. If the marker is not bright enough, you may change the Z_LEVEL parameter until the required intensity is displayed. When you are finally satisfied with the display brightness, rotate the dial and observe that the marker moves on top of the waveform - along the horizontal axis.

6. Move your marker to a point on the wave where you want to place your first point and press the autoline [1st Pt] push-button. The first point is now locked-in.

7. Now rotate the dial and observe that a second marker appears and that it moves on top of the wave along the horizontal axis. The line will be generated between the two markers when the second point is assigned. Move the cursor to the required location and when you are ready press the [2nd Pt] push-button. You will see that a line is automatically stretched between the two markers. If you are unhappy about the result, press [2nd] and then [UNDO] and the waveform is restore to its original shape.

NOTE

Note that after the [2nd Pt] push-button has been pressed, the first marker is internally relocated to the position of the second marker. This makes it extremely simple to generate straight

line waveforms by moving only one marker and pressing the [2nd Pt] push-button. Press the [1st Pt] push-button to terminate the automatic relocation of the first point.

8. If you modify the address parameter, the marker is moved on top of the wave and the corresponding data is displayed on the instrument. If you want to move the marker vertically, place the cursor on the SEG01_DAT parameter and change the data to the required coordinate. You'll see that the marker is then moved away from the wave along the vertical axis.

3-23-8. Changing the SYNC Address and the Z-Level

There are two parameters in the SYNC menu which control the sync address on the SYNC OUT connector, and the amplitude level for the rear panel Z-Axis output connector. The procedure of programming these parameters is given in the following.

1. Press the ARB WAVE PARAMETERS push-button until the light next to SYNC illuminates.

2. Press the [⇑] and [⇓] push-buttons simultaneously to display the 1st MENU. The following will be displayed:

SYNC_ON_SEG01
SYNC_ADD 00000

The first line indicates that the sync output will generate a sync signal somewhere on the waveform which is resident in segment number 01. If more than one segment are available, you may rotate the dial and set your sync signal on the required segment. The second line indicates the address location where the sync signal will appear. Rotate the dial to move the sync signal to the required location.

3. Scroll down to the next menu and observe that the display reading looks like the following:

SYNC_ADD 00000
Z_LEVEL -0.10V

The first line was already described above. The second line indicates the amplitude at the rear panel Z-Axis output.

3-23-9. Selecting Low-Pass Filter

Model 85 has a built-in three-range two-pole Bessel type filter. The filters may only be used in conjunction with the arbitrary waveforms. There are three low pass filters: 50KHz, 500KHz, and 5MHz. To select one of the required filter ranges, select the FILTER menu and rotate the dial until the required range is displayed. Place the ARB_FILTER parameter in range "0" (no filter) if you are not certain that you want to use filters, because it may cause undesired distortions in some waveforms.

3-23-10. Using the UNDO Function

The Undo function provides an option to restore the arbitrary waveform in the working memory to its latest condition. The Undo operates only on parameters in the LOAD and the UTIL'S menus which modify the data on the arbitrary waveform. The undo function is also available when you use the Auto Line command. It does not operate on any other function of the instrument. It is also disabled when a waveform is downloaded from a computer through the GPIB interface. The use of the Undo function is very simple. When you feel that you made a programming error and you would like to restore the last waveform, press [2nd] and then the [UNDO] push-button; the last operation will be cancelled, and the instrument will restore the arbitrary waveform to its previous shape.

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SECTION 4

GPIB OPERATION

4-1. INTRODUCTION

The GPIB (general purpose interface bus) is an instrumentation data bus with standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineering) in 1975 and given the IEEE-488 designation. In November 1987 the IEEE-488 document was revised, primarily for editorial classification and addendum, and the new document was identified as IEEE-488-1978.

This document has been the standard for general-purpose instrumentation bus (GPIB) which has been adopted by worldwide instrumentation manufacturers. In June 1987 the IEEE approved a new standard for programmable instruments and devices IEEE Standard 488.2-1987 Codes, Formats, Protocols, and Common Commands. The original document, IEEE-488-1978, was re-titled IEEE-488.1.

The IEEE-488.2 standard was designed to make the interface system easier to use by requiring that all devices provide certain capabilities such as talk and listen, respond to device clear commands, and be capable of service requests. Other functions such as parallel poll are left optional with the instrument manufacturer. The Model 8553 complies with all of the mandatory IEEE-488.1 and IEEE-488.2 requirements. Some of the issues which IEEE-488.2 Addresses are:

1. A required minimum set of IEEE-488.1 capabilities.
2. Reliable transfer of messages between a talker and listener and precise syntax in those messages.
3. A set of commands which would be useful in all instruments.
4. Common serial poll status reporting.
5. Synchronization programming with instrument functions.

This section contains general bus information as well as detailed programming information and is divided as follows:

1. General introductory information pertaining to the IEEE-488 bus may be found primarily in paragraphs 4-2 through 4-5.
2. Information necessary to connect the Model 8553 to the bus and to change the bus address is contained in paragraphs 4-6 and 4-7.
3. Programming of the instrument with general bus command is covered in paragraph 4-8.
4. Device-dependent command programming is described in detail in paragraph 4-10. The commands outlined in this section can be considered to be the most important since they control virtually all instrument functions.
5. Additional information pertaining to device status reporting and error messages can be found in paragraphs 4-13 and 4-15.

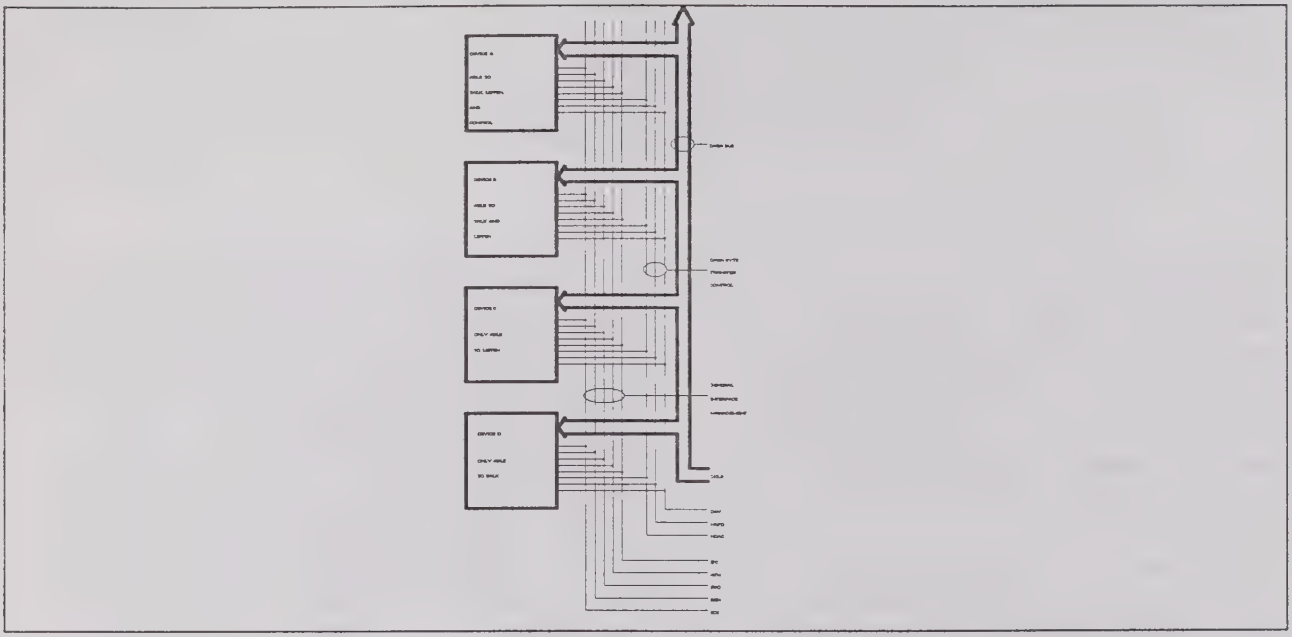
4-2. BUS DESCRIPTION

The IEEE-488 bus was designed as a parallel data transfer medium to optimize data transfer without using as excessive number of bus lines. In keeping with this goal, the bus has only eight data lines which are used for both data and most commands. Five bus management lines and three handshake lines round out the complement of signal lines. Since the bus is of parallel design, all devices connected to the bus have the same information available simultaneously. Exactly what is done with the information by each device depends on many factors, including device capabilities.

A typical bus configuration for remote controlled operation is shown in Figure 4-1. The typical system will have one controller and one or more instruments to which commands are given and from which data is received. There are three categories that describe device operation. These include: controller; talker; listener.

The controller controls other devices on the bus. A talker sends data, while a listener receives data. an instrument, may be a talker only, a listener only, or both a talker and listener.

Figure 4-1. IEEE Bus Configuration



Any given system can have only one controller (control may be passed to an appropriate device through a special command). Any number of talkers or listeners may be present up to the hardware constraints of the bus. The bus is limited to 15 devices, but this number may be reduced if higher than normal data transfer rates are required or if long interconnect cables are used.

Several devices may be commanded to listen at once, but only one device may be a talker at any given time. Otherwise, communications would be scrambled much like an individual is trying to select a single conversation out of a large crowd.

Before a device can talk or listen, it must be appropriately addressed. Devices are selected on the basis of their primary address. The addressed device is sent a talk or listen command derived from its primary address. Normally, each device on the bus has a unique primary address so that each may be addressed individually. The bus also has another addressing mode called secondary addressing, but not all devices use this addressing mode.

Once the device is addressed to talk or listen, appropriate bus transactions may be initiated. For example, if an instrument is addressed to talk, it will usually place its data on the bus one byte at a time. The listening device will then read this information, and the appropriate software is then be used to channel the information to the desired location.

4-3. IEEE-488 BUS LINES

The signal lines on the IEEE-488 bus are grouped into three general categories. The data lines handle bus information, while the handshake and bus management lines assure that proper data transfer and bus operation takes place. Each of the bus lines is "active low" so that approximately zero volts is a logic "one". The following paragraphs describe the purpose of these lines, which are shown in Figure 4-1.

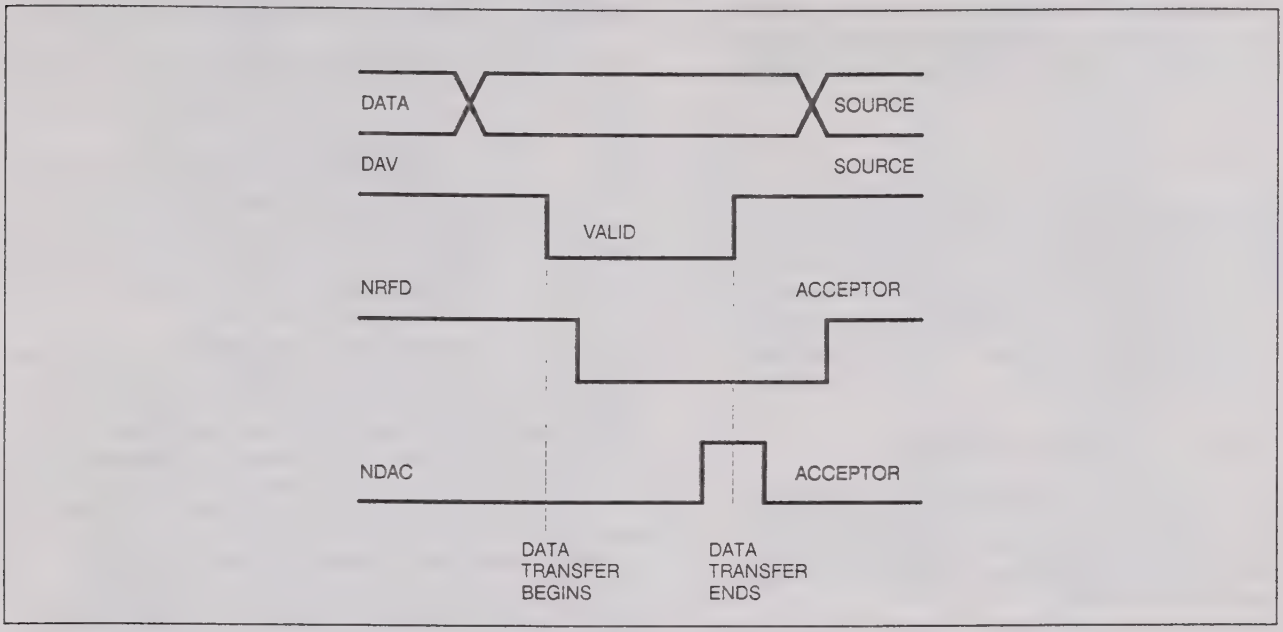
4-3-1. Bus Management Lines

The bus management group is made up of five signal lines that provide orderly transfer of data. These lines are used to send the uniline commands described in paragraph 4-8-1.

1. ATN (Attention) - the ATN line is one of the more important management lines. The state of the ATN line determines whether controller information on the data bus is to be considered data or a multiline command as described in paragraph 4-8-2.

2. IFC (Interface Clear) - Setting the IFC line true (low) causes the bus to go to a known state.

Figure 4-2. IEEE Handshake Sequence



3. REN (Remote Enable) - Setting the REM line low sends the REM command. This sets up instruments on the bus for remote operation.

4. EOI (End Or Identify) - The EOI line is used to send the EOI command that usually terminates a multi-byte transfer sequence.

5. SRQ (Service Request) - the SRQ line is set low by a device when it requires service from the controller.

4-3-2. Handshake Lines

The bus uses three handshake lines that operate in an interlocked sequence. This method assures reliable data transfer regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the handshake lines is controlled by the data source, while the remaining two lines are controlled by accepting devices. The three bus handshake lines are:

1. DAV (Data Valid) - The source controls the state of the DAV line.

2. NRFD (Not Ready For Data) - the acceptor controls the state of the NRFD line.

3. NDAC (Not Data Accepted) - the acceptor also controls the NDAC line.

The complete handshake sequence for one data byte is shown in Figure 4-2. Once data is on the bus, the source checks to see that NRFD is high, indicating that all devices on the bus are ready for data. At the same time NDAC should be low from the previous byte transfer. If these conditions are not met, the source must then wait until the NRFD and NDAC lines have the correct status. If the source is controller, NRFD and NDAC must remain stable for at least 100 ns after ATN is set low. Because of the possibility of bus hang up, some controllers have time-out routines to display error messages if the handshake sequence stops for any reason.

Once the NRFD and NDAC lines are properly set, the source sets the DAV line low, indicating that data on the bus is now valid. the NRFD line then goes low; the NDAC line goes high once all devices on the bus have accepted the data. Each device will release the NDAC line at its own rate, but the NDAC line will not go high until the slowest device has accepted the data byte.

After the NDAC line goes high, the source then sets the DAV line high to indicate that the data on the bus is no longer valid. At this point, the NDAC line returns to its low state. Finally, the NRFD line is released by each of the devices at their own rates, until the NRFD line finally goes high when the slowest

device is ready, and the bus is set to repeat the sequence with the next data byte.

The sequence just described is used to transfer both data and multiline command. The state of the ATN line determines whether the data bus contains data or commands.

4-3-3. Data Lines

The IEEE-488.2 bus uses the eight data lines that allow data to be transmitted and received in a bit-parallel, byte-serial manner. These eight lines use the convention DI01 through DI08 instead of the more common D0 through D7 binary terminology. The data lines are bi-directional and, as with the remaining bus signal lines, low is true.

4-4. INTERFACE FUNCTION CODES

The interface function codes are part of the IEEE-488.2 standards. These codes define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual.

Table 4-1 lists the codes for the Model 8553. The numeric value following each one or two letter code define Model 8553 capability as follows:

SH - (Source Handshake Function) - The ability for the Model 8553 to initiate the transfer of message/data on the data bus provided by the SH function.

AH - (Acceptor Handshake Function) - The ability for the Model 8553 to guarantee proper reception of message/data on the data bus provided by the AH function.

T - (Talker Function) - The ability of the Model 8553 to send device-dependent data over the bus (to another device) is provided by the T function. Model 8553 talker capabilities exist only after the instrument has been addressed to talk.

L - (Listen Function) - The ability of the Model 8553 to receive device-dependent data over the bus (from anther device) is provided by the L function. Listener function capability of the Model 8553 exist only after it has been addressed to listen.

RS - (Service Request Function) - The ability of the Model 8553 to request service from the controller is provided by the RS function.

RL - (Remote-Local Function) - The ability of the Model 8553 to be placed in remote or local modes is provided by the RL function.

Table 4-1. Model 8553 Interface Function Codes

CODE	INTERFACE FUNCTION
SH1	Source Handshake Function
AH1	Acceptor Handshake Capabilities
T6	Talker (basic talker, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service request capability
RL1	Remote/Local capability
PP2	Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
C0	No controller capability
E1	Open collector bus drivers
TE0	No Extended Talker capabilities
LE0	No Extended Listener capabilities

PP - (parallel Poll Function) - The ability of the Model 8553 to respond to a parallel poll request from the controller is provided by the PP function.

DC - (Device Clear Function) - The ability for the Model 8553 to be cleared (initialized) is provided by the DC function.

DT - (Device Trigger Function) - The ability of the Model 8553 to have its output triggered is provided by the DT function.

C - (controller Function) - The Model 8553 does not have a controller function.

TE - (Extended Talker Capabilities) - The Model 8553 does not have extended talker capabilities.

LE - (Extended Listener Function) - The Model 8553 does not have extended listener function.

4-5. SOFTWARE CONSIDERATIONS

The most sophisticated computer in the world would be useless without the necessary software. This basic requirement is also true of the IEEE-488.2 bus, which requires the use of handler routines as described in this paragraph. Before a controller can be used with the IEEE-488.2 interface, the user must make certain that appropriate handler software is present within the controller. With the IBM PC computer, for example, the GPIB interface card must be used with an additional software which contains the necessary handler software.

Other small computers that can be used as controllers have limited IEEE command capability. The capabilities of some computers depends on the particular interface being used. Often, little software "tricks" are required to achieve the desired results.

From the preceding discussion, the message is clear: make sure the proper software is being used with the instrument. Often, the user may incorrectly suspect that a hardware problem is causing fault, when it was the software that was causing the problem all along.

4-6. HARDWARE CONSIDERATIONS

Before the instrument can be used with the IEEE-488 bus, it must be connected to the bus with a suitable connector. Also, the primary address must be properly programmed as described in this section.

4-6-1. Typical Controlled Systems

The IEEE-488.2 bus is a parallel interface system. As a result, adding more devices is simply a matter of using more cables to make the desired connections. Because of this flexibility, system complexity can range from simple to extremely complex.

The simplest possible controlled system comprises a controller and one Model 8553. The controller is used to send commands to the instrument, which sends data back to the controller.

The system becomes more complex when additional instruments are added. Depending on programming, all data may be routed through the controller, or it may be transmitted directly from one instrument to another.

4-6-2. Connections

The instrument is connected to the bus through an IEEE-488.2 connector. This connector is designed to be stacked to allow a number of parallel connections on one instrument.

NOTE

To avoid possible mechanical damage, it is recommended that no more than three connectors be stacked on any one instrument. Otherwise, the resulting strain may cause internal damage to the connectors.

The IEEE-488.2 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is 20 meters. Failure to observe these limits will probably result in erratic bus operation.

Custom cables may be constructed using the information in Table 4-2. Table 4-2 also lists the contact assignments for the various bus lines.

Table 4-2. IEEE-488.1 Contact Designations

Contact Number	IEEE-488.1 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN	Management
18-24	Gnd	Ground

Contacts 18 through 24 are return lines for the indicated signal lines, and the cable shield is connected to contact 12. Each ground line is connected to digital common in the Model 8553.

CAUTION

The voltage between IEEE common and ground must not exceed 0 V or damage may result to your instrument.

4-7. CHANGING GPIB ADDRESS

The primary address of your instrument may be programmed to any value between 0 and 30 as long as the selected address is different from other devices addresses in the system. This may be accomplished using a front panel programming sequence. Note that the primary address of the instrument must agree with the address specified in the controller's program.

NOTE

The programmed primary address is briefly displayed during the power-up cycle of the Model 8553. It is stored in the non-volatile memory of the instrument and is retained even when power is turned off.

To check the present address, or to enter a new one, proceed as follows:

1.Depress the [2nd] push-button once then depress the [GPIB ADR] push-button. The display will be modified to display the following:

GPIB_ADDRESS xx

Where xx may be any number from 00 to 30.

2. Rotate the dial for selecting a new GPIB primary address.

3. To store the newly selected primary address depress [EXE]. The instrument then resumes normal operation.

4-8. BUS COMMANDS

While the hardware aspect of the bus is essential, the interface would be essentially worthless without appropriate commands to control the communications between the various instruments on the bus. This paragraph briefly describes the purpose of the bus commands, which are grouped into the following three categories:

1. Uniline commands: Sent by setting the associated bus line low (true).

2. Multiline commands: General bus commands which are sent over the data lines with the ATN line low (true).

3. Device-dependent commands: Special commands that depend on device configuration; sent over the data lines with ATN high (false).

4. Common commands and queries: A special set of commands that all devices must use and does not depend on device configuration; sent over the data lines in the same format as the device dependent commands.

4-8-1. Uniline Commands

Uniline commands are sent by setting the associated bus line to low. The ATN, IFC, and REN commands are asserted only by the system controller. The SRQ command is sent by an external device. The EOI command may be sent by either the controller or an external device depending on the direction of data transfer. The following is descriptions of each command.

REN - (Remote Enable) - The remote enable command is sent to the Model 8553 by the controller to set the instrument up for remote operation. Generally, this should be done before attempting to program the instrument over the bus. The Model 8553 will indicate that it is in the remote mode by illuminating

Table 4-3. IEEE-488 Bus Command Summary

COMMAND TYPE	COMMAND	STATE OF ATN LINE(*)	COMMENTS
Uniline	REN	X	Set up for remote operation
	EOI	X	Sent by setting EOI low
	IFC	X	Clears Interface
	ATN	Low	Defines data bus contents
	SRQ	X	Controlled by external device
Multiline Universal	LLO	Low	Locks out front panel controls
	DCL	Low	Returns device to default conditions
	SPE	Low	Enable serial polling
	SPD	Low	Disables serial polling Addressed
	SDC	Low	Returns unit to default condition
	GTL	Low	Returns to local control
	GET	Low	Triggers device for reading
Unaddress	UNL	Low	Removes all listeners from bus
	UNT	Low	Removes all talkers from bus
Device- Dependent(**)		High	Programs Model 8553 for various modes.

(*) X = Don't Care, (**) See paragraph 4-9 for complete description

its front panel REM indicator. To place the Model 8553 in the remote mode, the controller must perform the following steps:

1. Set the REN line true.
2. Address the Model 8553 to listen.

NOTE

Setting REN true without addressing will not cause the REM indicator to turn on; however, once REN is true, the REM light will turn on the next time an address command is received.

EOI (End Or Identify) - The EOI command is used to positively identify the last byte in a multi-byte transfer sequence. This allows variable length data words to be transmitted easily.

IFC (Interface Clear) - The IFC command is sent to clear the bus and set hand shake lines to a known state. Although device configurations differ, the IFC command usually places instruments in the talk and listen idle states.

ATN (Attention) - The controller sends ATN while transmitting addresses or multiline commands. Device-dependent commands are sent with the ATN line high (false).

SRQ (Service Request) - The SRQ command is asserted by an external device when it requires service from the controller. If more than one device is present, a serial polling sequence, as described in paragraph 4-8-2, must be used to determine which has requested service.

4-8-2. Universal Multiline Commands

Universal commands are multiline commands that require no addressing. All instrumentation equipped to implement the command will do so simultaneously when the command is transmitted over the bus. As with all multiline commands, the universal commands are sent over the data lines with ATN set low:

LLO (Local Lockout) - The LLO command is sent by the controller to remove the Model 8553 from the local operating mode. Once the unit receives the LLO command, all its front panel controls (except Power) will be inoperative.

NOTE

The REN bus line must be true before the instrument will respond to an LLO command.

To lock out the front panel controls of the Model 8553, the controller must perform the following steps:

1. Set ATN true.
2. Send the LLO command to the instrument.

DCL (Device Clear) - The DCL command may be used to clear the Model 8553, setting it to a known state. Note that all devices on the bus equipped to respond to a DCL will do so simultaneously. When the Model 8553 receives a DCL command, it will return to the default conditions listed in Table 4-4. Factory pre-selected parameters are listed in Table 3-1. To send a DCL command the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command on the bus.

SPE (Serial Poll Enable) - The serial polling sequence is used to obtain the Model 8553 status byte. Usually, the serial polling sequence is used to determine which of several devices has requested service over the SRQ line. However, the serial polling sequence may be used at any time to obtain the status byte from the Model 8553. For more information on status byte format, refer to paragraph 4-14. The serial polling sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The SPE (Serial Poll Enable) command is placed on the bus by the controller.
3. The Model 8553 is addressed to talk.
4. The controller sets ATN false.
5. The Model 8553 then places its status byte on the bus to be read by the controller.
6. The controller then sets the ATN line low and places SPD (Serial Poll Disable) on the bus to end the serial polling sequence.

Steps 3 trough 5 may be repeated for other instruments on the bus by using the correct talk address for each instrument. ATN must be true when the talk address is transmitted and false when the status byte is read.

SPD (Serial Poll Disable) - The SPD command is sent by the controller to remove all instrumentation on the bus from the serial poll mode.

4-8-3. Addressed Commands

Addressed commands are multiline commands that must be preceded by a listen command derived from the device's primary address before the instrument

Table 4-4. Default Conditions. (Status After SDC, DCL, or *RST)

Mode	Default	Status
Operating Mode	Normal	Normal operating mode
Sweep Direction	SWEEP_DIR 0	Start to stop
Trigger Modes	MODE 0	Normal continuous mode
Arbitrary Filter	ARB_FILTER 0	Filter disabled
Output Waveforms	WAVE 1	Sinewave output
Output Disable/Enable Mode	ST_BY 0	Output enabled
Displayed Menu	MAIN	First menu
Response Message Format	X0	Response header OFF
Response Message Terminator	Z0	New line(LF), ^END(EOI) terminator
Event Status Enable Mask	*ESE0	No mask
SRQ Enable Register Mask	*SRE0	No mask

will respond. Only the addressed device will respond to each of these commands:

SDC (Selective Device Clear) - The SDC command performs essentially the same function as the DCL command except that only the addressed device will respond. This command is useful for clearing only a selected instrument instead of all devices simultaneously. Model 8553 will return to the default conditions listed in Tables 3-1 and 4-4 when responding to an SDC command. To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 8553 to listen.
3. Place the SDC command on the data bus.

GTL (Go To Local) - The GTL command is used to remove the instrument from the remote mode of operation. Also, front panel control operation will usually be restored if the LLO command was previously sent. To send the GTL command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8553 to listen.
3. Place the GTL command on the bus.

NOTE

The GTL command does not remove the local lockout state. With the local lockout condition previously set, the GTL command will enable front panel control operation until the next time a listener address command is received. This places the Model 8553 in the local lockout state again.

GET (Group Execute Trigger) - The GET command is used to trigger or arm devices to perform a specific task depends on device configuration. Although GET is considered to be an addressed command, many devices respond to GET without being addressed. Using the GET command is only one of several methods that can be used to initiate a trigger. More detailed information on triggering can be found in Section 3 of this manual. To send GET command over the bus, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8553 to listen.
3. Place the GET command on the data bus.

GET can also be sent without addressing by omitting step 2.

4-8-4. Unaddress Commands

The two unaddress commands are used by the controller to simultaneously remove all talkers and listeners from the bus. ATN is low when these multiline commands are asserted.

UNL (Unlisten) - All listeners are removed from the bus at once when the UNL commands is placed on the bus.

UNT (Untalk) - The controller sends the UNT command to clear the bus of any talkers.

4-8-5. Device-dependent Commands

The meaning of the device-dependent commands is determined by instrument configuration. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function. For example, MODE2 is sent to the Model 8553 to place the instrument in the external trigger mode. The IEEE-488.2 bus treats device-dependent commands as data in providing that ATN is high (false) when the commands are transmitted.

4-8-6. Common Commands and Queries

Since most instruments and devices in an ATE system use similar commands which perform identical functions, the IEEE-488.2 document has specified a common set of commands and queries which all device must use. This avoids the problem in which devices from various manufacturers used a different set of commands to enable functions and report status. The IEEE-488.2 treats the common commands and queries as device dependent commands. For example, *TRG is sent over the bus to trigger the instrument. Some common commands and queries, however, are optional; most of them are mandatory. The following set of command groups ensure that all devices communicate uniformly:

1. System Data - These commands are used to store or retrieve information such as device identification, descriptions and options. It is possible to determine the manufacturer, model, and serial number of the device under remote control.

2. Internal Operation - These commands include such instrument operations as resetting, self-calibrating, and self-diagnostics of a GPIB device. The device may respond to a calibration query to indicate that the calibration was carried out successfully and report any calibration errors that may have occurred. The reset command sets the device-dependent functions to a known state and must not affect the state of the IEEE-488 interface, the Service Request Enable register, or Standard Event Status Enable register.

3. Status and Event - These commands control the status structure of the GPIB device and provide a means to read and enable events. Included in these commands are Clear, Event Status Enable, Power-on Status, and Service Request Enable.

4. Synchronization - The operation of the devices within the system are synchronized with these commands. Included is a Wait to Continue command which forces the devices to complete all previous commands and queries. The Operation Complete command tells the device to set bit 0 in the Standard Event Status register when it completes all pending operations.

5. Device Trigger - These commands enable a device to be triggered and specify how it responds to the trigger message. The Define Device Trigger command stores a sequence of commands which the device will follow when the Group Execute Trigger (GET) is received.

6. Stored Settings - These commands are used to save the state of the device under control, to be used at a later time. The Save command stores the present state of the device in the device's memory. If there is more than one location in which this data can be stored, the command is followed by a number which designates the storage register to use. The Recall command restores the state of the device, as stored in its memory from the previous Save command. As with the Save command, the Recall command must be followed by a number to specify the register from which the stored settings are to be recalled.

4-9. DEVICE LISTENING FORMATS

This paragraph discusses the formatting of <Program Message> elements received by a device from its system interface. Allowable IEEE-488.2 <Program Message> is composed of sequence of <Program Message> units, each unit representing a program command. Each program command is composed of a sequence of functional syntactic elements. Legal IEEE-488.2 program commands are created from functional elements sequences.

Some commands of universal instrument system application have been defined by the IEEE-488.2. They are the common commands; these commands and queries are specific path selections through the functional syntax diagram as specified in the IEEE-488.2 standard. The remaining commands are device-specific and are generated by the device designer using the functional syntax diagram and the needs of the device. The functional elements include separators, terminators, headers, and data types. These elements are discussed in the following.

4-9-1. Functional Element Summary

<Program Message> Represents a sequence of zero or more <Program Message Unit> elements separated by <Program Message Unit Terminator> elements.

<Program Message Unit> Represents a single command or programming data received by the device.

<Command Message Unit> Represents a single command or programming data received by the device.

<Query Message Unit> Represents a single query sent from the controller to the device.

<Program Data> Represents any of the six different program data types.

<Program Message Unit separator> Separates the <Program Message Unit> elements from one another in a <Program Message>.

<Program Data Separator> Separates sequential <Program data> elements that are related to the same header.

<Program Header Separator> Separates the header from any associated <Program Data>.

<Program Message Terminator> Terminates a <Program Message>.

<Command Program Header> Specifies function operation. Used with any associated <Program Data elements>.

<Query Program Header> Similar to <Command Program Header> except a query indicator (?) shows that a response is expected from the device.

<Character Program Data> A data type suitable for sending short mnemonic data, generally where a numeric data type is not suitable.

<Decimal Numeric Program Data> A data type suitable for sending decimal integers or decimal fractions with or without exponents.

<Suffix Program Data> An optional field following <Decimal Numeric Program Data> used to indicate associated multipliers and units.

<NonDecimal Numeric Program Data> A data type suitable for sending integer numeric representation in base 16, 8, or 2. Useful for data that is more easily interpreted when directly expressed in a non-decimal format.

<String Program Data> A data type suitable for sending 7-bit ASCII character strings where the content needs to be "Hidden" (by delimiters)

<Arbitrary Block Program Data> A data type suitable for sending blocks of arbitrary 8-bit information.

<Expression Program data> A data type suitable for sending data that is elevated as one or more non-expression data elements before further parsing.

4-9-2. Separator Functional Element Summary

The various elements within the <Program Message> are separated by ASCII characters that were specially assigned for this purpose. These separators are discussed in the following paragraphs.

4-9-2-1. Program Message Unit Separator

The <Program Message Unit Separator> separates sequential <Program Message Unit> elements from one another within a <Program Message>. The <Program Message Unit Separator> is defined as:

;

It is allowed to use leading <white space> elements before the <Program Message Separator>. <White Space> is defined as a single ASCII-encoded byte in the range of 00-09, 0B-20. This range includes the ASCII control characters and the space, but excludes the new line.

4-9-2-2. Program Data Separator

The <Program Data Separator> separates sequential <Program Data> elements from one another after a <Command Program Header> or <Query Program Header>. It is used when a <Command Program Header> or <Query Program Header> has multiple parameters. The <Program Data Separator> is defined as:

,

Preceding and succeeding <White Space> elements are permitted.

4-9-2-3. Program Header Separator

The <Program Header Separator> separates the <Command Program Header> or <Query Program Header> from the <Program Data> elements. The <Program Header Separator> is defined as white space:

<White Space>

Refer to paragraph 4-9-2-1 for the definition of <White Space> elements.

4-9-3. Program Message Terminator

A <Program Message Terminator> terminates a sequence of one or more definite length <Program Message Unit> elements. There are three possible <Program Message Terminator> elements:

1. NL (new line);
2. NL + ^END (EOI); and
3. ^END

NL is defined as a single ASCII-encoded byte 0A (10 decimal). Leading <White Space> elements are permitted. The instrument interprets any and all of

the three terminators as semantically equivalent. No alternative encoding are allowed. Note that IEEE-P981 amendment forbids the use of CR as a <Program Message Terminator> element. This is because some controller treat CR as the end of transmission and leave the LF character in the unit, thereby creating an error in the controller.

4-9-4. Command Program Header

The <Command Program Header> represents the operation to be performed in a device. The header may be optionally followed by associated parameters encoded as <Program Data> elements. There are three defined <Command Program Header> elements: <Simple Command Program Header>, <Compound Command Program Header>, and <Common Command Program Header.

<Simple Command Program Header> is defined as:

<Program Mnemonic>

For example, FRQ. Leading <White Space> elements are permitted. Upper/lower case alpha characters are treated with the same semantic equivalence. <Compound Command Program Header> is not used in model 8553 and will not be discussed here. A <Common Command Program Header> is defined as:

***<Program Mnemonic>**

For example, *TRG. Leading <White Space> elements are permitted. Upper/ lower case alpha characters are treated with the same semantic equivalence.

4-9-5. Query Program Header

The <Query Program Header> represents the operation to be performed in a device. A <Query Program Header> causes the device to generate a response. This element may be optionally followed by associated parameters encoded as <Program Data> elements. There are three defined <Query Program Header> elements: <Simple Query Program Header>, <Compound Query Program Header>, and <Common Query Program Header. A <Simple Query Program Header> is defined as:

<Program Mnemonic>?

For example, FRQ?. Leading <White Space> elements are permitted. Upper/lower case alpha characters are treated with the same semantic equivalence. <Compound Query Program Header> is not used in model 8553 and will not be discussed here. A <Common Query Program Header> is defined as:

***<Program Mnemonic>?**

For example, *CAL?. Leading <White Space> elements are permitted. Upper/lower case alpha characters are treated with the same semantic equivalence.

4-9-6. Program Data

A <Program Data> functional element is used to convey a variety of parameter information related to the <Program Header>.

4-9-6-1. Character Program Data

The <Character Program Data> functional element is not implemented in Model 8553. Therefore it shall not be discussed in this manual.

4-9-6-2. Decimal Numeric Program Data

The <Decimal Numeric Program Data> is a flexible version of the three numeric representations as defined in ANSI X3.42-1975 - NR1, NR2, and NR3. A <Decimal Numeric Program Data> elements are defined as:

1. **NR1** elements consists of a set of implicit point representations of numeric values. i.e. (+/-)12345.
2. **NR2** elements are the representations of explicit point numeric values. i.e. (+/-)12.345.
3. **NR3** elements are representations of scaled explicit radix point numeric values together with an exponent notation. i.e. (+/-)123.456E(+/-)3.

4-9-6-3. Suffix Program Data

A <Suffix Program Data> element permits the use of a suffix following the <Decimal Numeric Program Data> (NRf). The suffix expression associated units and (optional) multipliers that modify how the NRf is interpreted by the device. The presence of a <Suffix Program Data> after an NRf is always optional. No particular <Command Program Header> or <Query Program Header> is a device shall require the use of a <Suffix Program Data> element.

4-9-6-4. Non-Decimal Numeric Program Data

The <Non-Decimal Program Data> functional element is not implemented in Model 8553. Therefore it shall not be discussed in this manual.

4-9-6-5. Arbitrary Block Program Data

The <Arbitrary Block Program Data> functional element allows any 8-bit bytes (including extended ASCII codes) to be transmitted in a message. This element is particularly useful for sending large quantities of data. This element represents a general purpose solution to the transmission of 8-bit binary data. Model 8553 uses this element to transmit its waveform data to the controller.

There are two possible methods of using the <Arbitrary Block Program Data> element: as part of a <Program Message>, regardless of the location of this element, or at the end of a <Program Message>, where with the second option, the <Arbitrary Block Program Data> element must terminate the transmission sequence by sending NL+^END.

The <Arbitrary Block Program Data> element is defined as:

#<non-zero digit>

The value of the <non-zero digit> element equals the number of <digit> elements which follow. The value of the <digit> element taken together as a decimal integer equals the number of <8-bit data byte> elements which follow. If the IEEE-488.1 END message is received before the specified number of bytes has been received, a Command error is reported to the relevant status register.

The <Arbitrary Block Program Data> element is also defined as:

#<0>

This format is especially useful when the length of the transmission is unknown or when transmission speed or other considerations prevent segmentation into definite length blocks. The use of this element requires NL+^END and forces immediate termination of the <Program Message>.

4-9-6-6. Expression Program Data

The <Expression Program Data> functional element is not implemented in Model 8553. Therefore it shall not be discussed in this manual.

4-10. DEVICE-DEPENDENT COMMAND PROGRAMMING

IEEE-488.2 device-dependent commands are sent to the Model 8553 to control various operating conditions such as display modify, operating mode, output and parameter interrogate. Each command is made up of a program, command or query header followed by program data, program suffix, and terminated by program message terminator. The IEEE bus treats device-dependent commands as data in, providing that ATN is high when the commands are transmitted. For example the output amplitude is programmed by sending the following <Program Message Unit>: AMPL 10.5V.

A number of <Program Message Unit> elements may be grouped together in one <Program Message> provided that each <Program Message Unit> is separated by a <Program Message Unit Separator>. <Program message Unit> elements within a <Program Message> are executed **exactly** in the same order they are received from the controller. The Model 8553 ignores all non-printable ASCII characters (00 HEX through 20 HEX) except the "CR" (carriage return). A command string is terminated by a <Program Message Terminator> which tells the instrument to execute the <Program Message>.

If an illegal <Program Header> or <Program Data> is present within a <Program Message>, the instrument will:

1. Ignore the illegal part or the <Program Message> (but will execute the rest of the <Program Message>).
2. Display an appropriate front panel error message.
3. Set certain bits in its status registers.
4. Generate an SRQ if programmed to do so.

Device-dependent programming aspects are covered in paragraph 4-8-5 and 4-10.

NOTE

Before programming the instrument over the bus, It is recommended that the instrument be set to its default values by sending an SDC or DCL over the bus. See paragraph 4-8-3 for information on using the SDC command.

In order to send a device-dependent or a common command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8553 to listen.
3. Set ATN false.
4. Send the command string over the data bus one byte at a time.

Table 4-5. Device-Dependent Command Summary

Mode	Program Header and Data	Description	Suffix* Data
PROGRAM GENERAL MODES			
OPERATING MODE			
	NORMAL	Normal operation	
	LIN_SWEEP	Linear sweep	
	LOG_SWEEP	Logarithmic sweep	
	PLL	Phase lock loop	
CONTROL MODES			
	NORMAL	Off, no external control	
	AM	AM	
	FM	FM	
	VCO	Voltage controlled oscillator	
TRIGGER MODES			
	MODE 0	Normal continuous mode	
	MODE 1	Internal trigger	
	MODE 2	External trigger	
	MODE 3	External gate	
OUTPUT WAVEFORMS			
	WAVE 0	Sinewave	
	WAVE 1	Triangle	
	WAVE 2	Squarewave	
	WAVE 3	Fixed base-line positive squarewave	
	WAVE 4	Fixed base-line negative squarewave	
	WAVE 5	Arbitrary waveform	
OUTPUT MODE			
	ST_BY 0	Normal output	
	ST_BY 1	Disabled output	
PROGRAM GENERAL PARAMETERS			
MAIN MENU			
	FREQ	Program output frequency	MHZ, HZ, KHZ, MAHZ
	AMPL	Program output amplitude	MV, V
	OFFS	Program output offset	MV, V
TRIG MENU			
	TRIG_LEV	Program trigger level	V
	TRIG_SLOP	Program trigger slope	
	TRIG_PHAS	Program trigger phase	DEG
	TRIG_COUN	Program counted triggers (burst)	
	INT_PER	Program internal trig. generator per.	NS, US, MS, S
SWEEP MENU			
	SWEEP_DIR 0	Sweep direction - start to stop (up)	
	SWEEP_DIR 1	Stop to start (down)	
	SWEEP_DIR 2	Start to stop to start (up-down)	

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description	Suffix* Data
	SWEEP_DIR 3	Stop to start to stop (down-up)	
	START	Program sweep start frequency	MHZ, HZ, KHZ, MAHZ
	STOP	Program sweep stop frequency	MHZ, HZ, KHZ, MAHZ
	TIME	Program sweep time	MS, S
	MARK	Program sweep marker frequency	MHZ, HZ, KHZ, MAHZ
PHASE MENU			
	EXT_REF/	Program frequency division factor	
	PHAS_OFFS	Program phase offset	DEG
STATUS			
	RST_FUNC	Reset function generator parameters	
PROGRAM ARBITRARY MEMORY MANAGEMENT PARAMETERS			
SET-UP MENU			
	MEM_PART	Program memory partition table	
	SEG01=d	Assign memory size (d) to segment 01	
SEQU MENU			
	SEQ_STEP	Program number of sequencer steps	
	STEP01=SEG01*d	Assign multiplier (d) to segment 01 in sequencer step 01	
PROGRAM ARBITRARY WAVEFORM PARAMETERS			
CLOCK MENU			
	SAMPLE_RATE	Program digital sampling rate	MSPS,SPS,KSPS,MASPS
	WAVE_FREQ	Program arbitrary wave frequency	MHZ, HZ, KHZ, MAHZ
	WAVE_PERIOD	Program arbitrary wave period	MS, S, KS, MAS
DATA MENU			
	SEG01_ADDn_DATd	Write data (d) to address (n) in segment 01	
SYNC MENU			
	SYNC_ON_SEG01	Program SYNC output to sync on segment 01	
	SYNC_ADDd	Program SYNC address (d) on output	
	Z_LEVEL	Program amplitude at Z-axis output	
FILTER MENU			
	ARB_FILTER 0	No filter on arbitrary waveform	
	ARB_FILTER 1	5MHz filter on arbitrary waveform	
	ARB_FILTER 2	500KHz filter on arbitrary waveform	
	ARB_FILTER 3	50KHz filter on arbitrary waveform	
PROGRAM ARBITRARY WAVEFORM			
	SEG01_DATA#d	Send complete arbitrary waveform string to segment 01, as part of <Program Message>	
	SEG01_DATA#0	Send complete arbitrary waveform string to segment 01, terminated with NL+^END	

* Suffix Data is optional.

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description	Suffix* Data
PROGRAM DIGITIZER PARAMETERS			
HORIZ MENU			
	RATE	Program sampling rate	Msps, sps, Ksps, MAsps
VERT MENU			
	FULL_SCALE	Program dizitizer window level	V
TRIG MENU			
	TRIG_SRC0	Select Internal trigger source	
	TRIG_SRC1	Select external trigger source	
	TRIG_SRC2	Select manual trigger source	
	INT_TRIG_LEV	Program digitizer internal trigger level	V
	EXT_TRIG_LEV	Program digitizer external trigger level	V
	DIG_TRIG_SLOP0	Select positive going edge sensitivity	
	DIG_TRIG_SLOP1	Select negative going edge sensitivity	
	TRIG_DEL0	Select no trigger delay	
	TRIG_DEL1	Select pre-trigger delay	
	TRIG_DEL2	Select post-trigger delay	
	PRE_TRIG	Program pre-trigger delay	
	POST_TRIG	Program post-trigger delay	
	SEG01_DIG_EXE	Arm digitizer to take samples for segment 01	
REVIEW PARAMETER			
REVIEW MAIN MENU			
	V_FREQ	Display output frequency	
	V_AMPL	Display output amplitude	
	V_OFFS	Display output offset	
REVIEW TRIG MENU			
	V_TRIG_LEV	Display trigger level	
	V_TRIG_SLOP	Display trigger slope	
	V_TRIG_PHAS	Display trigger phase	
	V_TRIG_COUN	Display counted triggers (burst)	
	V_INT_PER	Display internal trigger generator period	
REVIEW SWEEP MENU			
	V_SWEEP_DIR	Display sweep direction	
	V_START	Display sweep start frequency	
	V_STOP	Display sweep stop frequency	
	V_TIME	Display sweep time	
	V_MARK	Display sweep marker frequency	
REVIEW PHASE MENU			
	V_EXT_REF/	Display frequency division factor	
	V_PHAS_OFFS	Display phase offset	

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description
REVIEW SET-UP MENU		
	V_MEM_PART	Display memory partition table
	V_SEG01	Display memory size of segment 01
REVIEW SEQU MENU		
	V_SEQ_STEP	Display number of sequencer steps
	V_STEP01	Display sequencer step 01
REVIEW CLOCK MENU		
	V_SAMPLE_RATE	Display digital sampling rate
	V_WAVE_FREQ	Display arbitrary wave frequency
	V_WAVE_PERIOD	Display arbitrary wave period
REVIEW DATA MENU		
	V_SEG01_ADDn	Display data value is address location (n) of segment 01
REVIEW SYNC MENU		
	V_SYNC_ON_SEG	Display SYNC output segment location
	V_SYNC_ADD	Display SYNC address
	V_Z_LEVEL	Display Z- level amplitude
REVIEW FILTER MENU		
	V_ARB_FILTER	Display filter option
REVIEW DIGITIZER PARAMETERS		
REVIEW HORIZ MENU		
	V_RATE	Display sampling rate
REVIEW VERT MENU		
	V_FULL_SCALE	Display dizitizer window level
REVIEW TRIG MENU		
	V_TRIG_SRC	Display trigger source
	V_INT_TRIG_LEV	Display digitizer internal trigger level
	V_EXT_TRIG_LEV	Display digitizer external trigger level
	V_DIG_TRIG_SLOP	Display edge sensitivity
	V_TRIG_DEL	Display trigger delay
	V_PRE_TRIG	Display pre-trigger delay
	V_POST_TRIG	Display post-trigger delay
RESPONSE DATA QUERY		
	FREQ?	Interrogate output frequency
	AMPL?	Interrogate output amplitude
	OFFS?	Interrogate output offset
	TRIG_LEV?	Interrogate trigger level
	TRIG_SLOP?	Interrogate trigger slope
	TRIG_PHAS?	Interrogate trigger phase
	TRIG_COUN?	Interrogate counted triggers (burst)
	INT_PER?	Interrogate internal trig. generator period

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description
	SWEEP_DIR?	Interrogate sweep direction
	START?	Interrogate sweep start frequency
	STOP?	Interrogate sweep stop frequency
	TIME?	Interrogate sweep time
	MARK?	Interrogate sweep marker frequency
	EXT_REF/?	Interrogate frequency division factor
	PHAS_OFFS?	Interrogate phase lock offset
	MEM_PART?	Interrogate memory partition table
	SEG01?	Interrogate segment size
	SEQ_STEP?	Interrogate number of sequencer steps
	STEP01?	Interrogate step
	SAMPLE_RATE?	Interrogate digital sampling rate
	WAVE_FREQ?	Interrogate arbitrary wave frequency
	WAVE_PERIOD?	Interrogate arbitrary wave period
	SEG01_ADDn_DAT?	Interrogate data value in address (n) of segment 01
	SYNC_ON_SEG?	Interrogate SYNC segment location
	SYNC_ADD?	Interrogate SYNC address on output
	Z_LEVEL?	Interrogate amplitude at Z-axis output
	ARB_FILTER?	Interrogate filter on arbitrary waveform
	STATUS?	Interrogate machine status
	TRIG_SRC?	Interrogate trigger source
	INT_TRIG_LEV?	Interrogate digitizer internal trigger level
	EXT_TRIG_LEV?	Interrogate digitizer external trigger level
	DIG_TRIG_SLOP?	Interrogate edge sensitivity
	TRIG_DEL?	Interrogate trigger delay
	PRE_TRIG?	Interrogate pre-trigger delay
	POST_TRIG?	Interrogate post-trigger delay
WAVEFORM_DATA_QUERY		
	SEG01_DATA1?	Receive complete arbitrary waveform string from segment 01, as part of <Program Message>
	SEG01_DATA0?	Receive complete arbitrary waveform string from segment 01, terminated with NL+^END
RESPONSE_MESSAGE_FORMAT		
	X0	Response header OFF
	X1	Response header ON
	Z0	New line (LF), END (EOI) terminator
	Z1	New line (LF) terminator
	Z2	END (EOI) terminator
COMMON_COMMANDS		
	*CLS	Clear status command
	*ESE	Standard event status enable command
	*OPC	Operation complete command
	*RCL	Recall front panel set-up command
	*RST	Reset command
	*SAV	Save front panel set-up command

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description
	*SRE	Service request enable command
	*TRG	Trigger command
	*WAI	Wait-to-continue command
COMMON QUERIES		
	*CAL?	Calibration query
	*ESE?	Standard event status enable query
	*ESR?	Standard event status register query
	*IDN?	Identification query
	*OPC?	Operation complete query
	*SRE?	Service request enable query
	*STB?	Read status byte query
	*TST?	Self-test query
STANDARD EVENT STATUS ENABLE REGISTER MASK		
	*ESE0	No mask
	*ESE1	ESB bit set on operation complete
	*ESE2	Not used
	*ESE4	ESB bit set on query error
	*ESE8	ESB bit set on device dependent error
	*ESE16	ESB bit set on execution error
	*ESE32	ESB bit set on command error
	*ESE64	ESB bit set on user request
	*ESE128	ESB bit set on power on
CALIBRATION FAILURE STATUS BYTE A MASK		
	FSA0 through FSA16383	Mask not available
CALIBRATION FAILURE STATUS BYTE B MASK		
	FSB0 through FSB255	Mask not available
SERVICE REQUEST ENABLE REGISTER MASK		
	*SRE0	No mask
	*SRE1	RQS/MSS bit set on ERR bit
	*SRE2	RQS/MSS bit set on FSC bit (fail status byte C)
	*SRE4	RQS/MSS bit set on FSB bit (fail status byte B)
	*SRE8	RQS/MSS bit set on FSA bit (fail status byte A)
	*SRE16	RQS/MSS bit set on MAV bit (message available)
	*SRE32	RQS/MSS bit set on ESB bit (standard event status register)
	*SRE128	Not used

NOTE

REN must be true when attempting to program the Model 85.

Device-dependent commands that affect Model 85 are listed in Table 4-5. Common commands and queries are also listed in Table 4-5. All the commands listed in the Tables 4-5 are covered in detail in the following.

4-11. GENERAL MODES PROGRAMMING

4-11-1. Operating Mode

The operating mode command controls the mode that model 85 operates in. Operator may select between four different operating modes: normal operating mode, linear sweep mode, logarithmic sweep mode, and phase locking generator mode.

The model 85 operating mode may be programmed by sending one of the following commands. The numbers in parenthesis represent the status number of the Operating Modes, as appear in the Machine Status String - STATUS.

NORMAL = Normal operating mode (0)
LIN_SWEEP = Linear sweep mode (1)
LOG_SWEEP = Logarithmic sweep mode (2)
PLL = Phase locking generator mode (3)

4-11-2. Control Modes

Model 85 provides three control modes: FM, AM, and VCO. The control mode command gives the user control over the control mode of the function generator. Program the Model 85 to one of the control modes by sending one of the following commands. The numbers in parenthesis represent the status number of the Control Modes, as appear in the Machine Status String - STATUS.

NORMAL = Normal operating mode (0)
FM = Frequency modulation mode (1)
AM = Amplitude modulation mode (2)
VCO = VCO mode (3)

4-11-3. Trigger Modes

The trigger mode command gives the user control over the input stimulant of the Model 85. There are a number of acceptable external sources for stimulating the output of the function generator. The instrument may also be set to operate in continuous mode or with having an internal trigger source. The generator may be programmed to accept either an external stimulant or an internal stimulant. Program the Model

Mode	Program Header and Data	Description
COMMON COMMANDS	*CLS	Clear status command
	*ESEn	Standard event status enable command
	*OPC	Operation complete command
	*RCLn	Recall front panel set-up command
	*RST	Reset command
	*SAVn	Save front panel set-up command
	*SREn	Service request enable command
	*TRG	Trigger command
	*WAI	Wait-to-continue command
COMMON QUERIES	*CAL?	Calibration query
	*ESE?	Standard event status enable query
	*ESR?	Standard event status register query
	*IDN?	Identification query
	*OPC?	Operation complete query
	*SRE?	Service request enable query
	*STB?	Read status byte query
	*TST?	Self-test query

Table 4-6. Common Commands and Queries Summary

85 to one of the trigger modes by sending one of the following commands. The numbers in parenthesis represent the status number of the Trigger Modes, as appear in the Machine Status String - STATUS.

MODE 0 = Normal continuous mode (0)
MODE 1 = Internal trigger (1)
MODE 2 = External trigger (2)
MODE 3 = External gate (3)

4-11-4. Output Waveforms

The output waveform command give the user control over the output waveform. The seven parameters which are associated with the waveform commands, set the instrument to output sinewave, triangle, squarewave, positive pulse, negative pulse, and arbitrary waveforms. The output waveform may be programmed by sending one of the following commands. The numbers in parenthesis represent the status number of the Output Waveforms, as appear in the Machine Status String - STATUS.

WAVE 0 = Sinewave (0)
WAVE 1 = Triangle (1)
WAVE 2 = Square wave (2)
WAVE 3 = Fixed base-line positive square wave (3)
WAVE 4 = Fixed base-line negative square wave (4)
WAVE 5 = Arbitrary waves (5)

4-11-5. Output Mode

The output mode command places the function generator in stand by mode. The output mode may be programmed by sending one of the following commands. The numbers in parenthesis represent the status number of the Output Mode, as appears in the Machine Status String - STATUS.

ST_BY 0 = Normal output
ST_BY 1 = Disabled output

4-12. GENERAL PARAMETERS PROGRAMMING

The parameter programming command sets the function generator to the various levels which are required for the unit under test. There are various parameters which may be modified using this command. The command message unit is comprised of three parts: the <command program header>, the <decimal numeric program data>, the <suffix program data> (optional), and the <program message terminator>.

The <command program header> mnemonic is independent of control location on the front panel but relates to front panel nomenclature. For example, FRQ mnemonic is related to front panel Frequency marking.

The <decimal numeric program data> is a flexible version of numeric representation denoted by NRf. Operator may choose to program <decimal numeric program data> using NR1, NR2, or NR3 formats. Examples of the various <decimal numeric program data> is given in the following.

NR1 elements consists of a set of implicit point representations of numeric values. i.e. (+/-)12345.

NR2 elements are the representations of explicit point numeric values. i.e. (+/-)12.345.

NR3 elements are representations of scaled explicit radix point numeric values together with an exponent notation. i.e. (+/-)123.456E(+/-)3.

The <suffix program data> element permits the use of suffix following the NRf. The suffix expresses associated units and (optional) multipliers that modify how the NRf is interpreted by the device.

For example, to program the model 85 for a frequency output of 10.7 MHz, the following <program message unit> options may be used:

FRQ 10.700000; or
FRQ 10.7MAHZ; or
FRQ 10.7E+6; or
FRQ 10.7E6HZ; etc.

<Command program header> and <suffix program data> and (optional) multipliers summary is given in the following

Function Generator General Parameters

FREQ ...MHZ, HZ, KHZ, MAHZ = Program frequency parameter.
AMPL ...MV, V = Program amplitude parameter.
OFFS ...MV, V = Program offset parameter.

TRIG_LEV ...V = Program trigger level parameter.
TRIG_SLOP = Program trigger slope parameter.
TRIG_PHAS ...DEG = Program trigger start phase parameter.
TRIG_COUN = Program counted triggers parameter.
TRIG_PER ...MS, S = Program period of built-in trigger generator parameter.
SWEEP_DIR = Program sweep direction parameter.
START ...MHZ,HZ,KHZ,MAHZ = Program sweep start frequency.

STOP ...MHZ, HZ, KHZ, MAHZ = Program sweep stop frequency.
TIME ...NS, US, MS, S = Program sweep time parameter.
MARK ...MHZ, HZ, KHZ, MAHZ = Program sweep marker parameter.

EXT_REF/ = Program external frequency division factor.
PHAS_OFFS ...DEG = Program phase lock offset parameter.
RST_FUNC = Rest function generator parameters to their defaults. This command was specially designed for use with WaveCAD programming. It does not replace the *RST, SDC or DCL commands.

Arbitrary Memory Management Parameters

MEM_PART = Program memory partition table.
SEG_01=n = Program memory length (n) for the selected segment.
SEQ_STEP = Program number of sequencer steps.
STEP01=SEG01*d = Assign multiplier (d) to segment 01 in sequencer step 01.

Arbitrary Waveform Parameters

SAMPLE_RATE ...MSPS, SPS, KSPS, MASPS = Program arbitrary waveform clock rate parameter.
WAVE_FREQ ...MHZ, HZ, KHZ, MAHZ = Program arbitrary waveform frequency parameter.
WAVE_PERIOD ...NS, US, MS, S = Program arbitrary waveform period parameter.

SEG01_ADDn_DATd = Write data (d) to address address location (n) of segment 01.

SYNC_ON_SEG01 = Program SYNC output to sync on specific segment.
SYNC_ADDd = Program sync address (d) on arbitrary waveform.
Z_LEVEL ...V = Program amplitude of Z-axis output.

ARB_FILTER = Program filter band on arbitrary waveform.

The programming limits for each of the above parameters are listed in Table 3-2. After DCL or SDC, the instrument defaults to its factory selected values. Factory defaults are listed in Table 3-1 and 4-4.

Arbitrary Waveform Data

SEG01_DATA#d = Send complete arbitrary waveform data string to segment 01, as part of a <Program Message> element. The arbitrary waveform data is sent to the instrument in binary code. "d" defines for the instrument how many bytes of data will follow. When using this method of arbitrary data transfer, it is not necessary to terminate the transmission sequence after the waveform data has been sent as other <Program Message Unit> elements may follow the transmission of the waveform data in the same <Program Message>.

SEG01_DATA#0 = Send and terminate a complete arbitrary waveform data string to segment 01. The arbitrary waveform data is sent to the instrument in binary code. "0" defines for the instrument that the binary transmission is terminated, immediately after the waveform data has been sent, by NL+^END terminators. Using this transmission method, it is not necessary for the programmer to group the arbitrary waveform data and count the number of data bytes that will be sent to the instrument. Other <Program Message Unit> elements can not follow the transmission of the waveform data in the same <Program Message>.

Digitizer Parameters

RATE ...MSPS, SPS, KSPS, MASPS = Program digitizing sampling rate.
FULL_SCALE ...V = Program dizitizer window level.
TRIG_SRC = Select trigger source. Internal (0); External (1); or Manual (2).
INT_TRIG_LEV ...V = Program digitizer internal trigger level.
EXT_TRIG_LEV ...V = Program digitizer external trigger level.
DIG_TRIG_SLOP = Select edge sensitivity. Positive (0); or Negative (1).
TRIG_DEL = Select trigger delay option. None (0); Pre-trigger (1); or Post-trigger (2).
PRE_TRIG = Program pre-trigger delay.
POST_TRIG = Program post-trigger delay.
SEG01_DIG_EXE = Arm digitizer to take samples for segment 01.

4-13. REVIEW PARAMETER

The review parameter command controls what the Model 85 places on the display.

V_FREQ = Display output frequency parameter.
V_AMPL = Display output amplitude parameter.
V_OFFS = Display output offset parameter.

V_TRIG_LEV = Display trigger level parameter.
V_TRIG_SLOP = Display trigger slope parameter.
V_TRIG_PHAS = Display trigger start phase parameter.

V_TRIG COUN = Display counted trigger (burst) parameter.
V_INT_PER = Display period of internal trigger generator parameter.

V_SWEEP_DIR = Display sweep direction parameter.
V_START = Display sweep start parameter.
V_STOP = Display sweep start parameter.
V_TIME = Display sweep time parameter.
V_MARK = Display sweep marker parameter.

V_EXT_REF/ = Display frequency division parameter.
V_PHAS_OFFS = Display phase offset parameter.

V_MEM_PART = Display memory partition table parameter.
V_SEG01 = Display memory size of segment.
V_SEQ_STEP = Display number of sequencer steps parameter.
V_STEP01 = Display sequence of sequencer step.

V_SAMPLE_RATE = Display digital sampling rate parameter.
V_WAVE_FREQ = Display arbitrary wave frequency parameter.
V_WAVE_PER = Display arbitrary wave period parameter.

V_SEG01_ADDn = Display data value in address location (n) of segment 01.

V_SYNC_ON_SEG = Display sync output segment location parameter.
V_SYNC_ADD = Display sync address parameter.
V_Z_LEVEL = Display Z- level amplitude parameter.
V_ARB_FILTER = Display filter option parameter.

Review Digitizer Parameters

V_RATE = Display digitizer sampling rate.
V_FULL_SCALE = Display dizitizer window level.
V_TRIG_SRC = Display digitizer trigger source.
V_INT_TRIG_LEV = Display digitizer internal trigger level.
V_EXT_TRIG_LEV = Display digitizer external trigger level.
V_DIG_TRIG_SLOP = Display digitizer edge sensitivity.
V_TRIG_DEL = Display digitizer trigger delay option.
V_PRE_TRIG = Display digitizer pre-trigger delay.
V_POST_TRIG = Display digitizer post-trigger delay.

4-14. COMMON COMMANDS

As discussed in previous paragraphs most instruments and devices in an ATE system use similar commands which perform identical functions to avoids the problem in which devices from various manufacturers used a different set of commands to enable functions and report status. Some common commands and queries, however, are optional; most of them are mandatory. Common commands and queries are listed in Table 4-6. The following set of common commands are utilized in the model 85 (optional common commands that are not included in the model 85 command set will not be discussed here).

***CLS** (Clear Status Command) - clears status data structures, and forces the device to the Operation Complete Command/Query Idle State. If the Clear Status command immediately follows a <Program Message Terminator>, the Output Queue and the MAV bit will be cleared.

***ESE** (Standard Event Status Enable Command) - followed by a number in the range of 0 to 255, sets the Standard Event Status Enable Register bits. The binary equivalent of the number represents the values of the individual bits set into the Standard Event Status Enable register.

***OPC** (Operation complete Command) - causes the device to generate the operation complete message in the Standard Event Status Register when all pending selected device operations have been finished.

***RCL** (Recall Command) - restores the state of the device to a state previously stored in the device's memory. If the device has more than one memory register, the command must be followed by a number to specify which register is to be used. The functions restored by the *RCL command are the same as those affected by the *RST command. Model 85 may recall settings in registers designated with numbers from 00 to 30.

***RST** (Reset) - Sets device-dependent functions to a known state, purges all *OPC commands and queries, and aborts all pending operations. The output queue, Service Request Enable Register, Standard Event Status Enable Register, and power-on flag are not affected. Device defaults are listed in Table 4-4

***SAV** (Save Command) - allows the user to store the present state of a device in local memory. If the device has more than memory location, the command must be followed by a number to designate the storage register to be used. Model 85 may store settings in registers designated with numbers from 00 to 30.

***SRE** (Service Request Enable Command) - followed by a number, sets the Service Request Enable register which determines what bit in the status byte will cause a service request from the device. The

binary equivalent of the number represents the values of the individual bits of the Service Request Enable Register.

***TRG** (Trigger Command) - has exactly the same effect as a GET when received, parsed, and executed by the device.

***WAI** (Wait to Continue Command) - causes a device to wait until all previous commands and queries are completed before executing any which follow the *WAI command.

4-14-1. Set-ups (*SAV, *RCL)

The set-ups commands select the memory location where front panel setup is to be stored (*SAV) or from where recalled (*RCL). To store or recall a setup use one of the following commands:

***SAVn**
***RCLn**

Where n may range from 0 to 9. n is the selected memory cell of which the setup is to be stored or from where the setup is to be recalled.

4-15. DEVICE TALKING FORMATS

This paragraph discusses the formatting of <Response Message> elements sent from a device via its system interface. Allowable IEEE-488.2 response message is composed of a sequence of <Response Message> units, each unit representing a response to a query. Each <Response Message> is composed of a sequence of functional syntactic elements. Legal IEEE-488.2 <Response Message> is created from functional elements sequences. A <Response Message is interpreted by a controller running an application program, and as such, needs to convey its information precisely for consistent operation with a wide range of controllers. A <Response Message>, therefore, has a more restrictive format than a <Program Message>.

Some queries of universal instrument system application have been defined by the IEEE-488.2. They are the common queries; these queries are specific path selections through the functional syntax diagram as specified in the IEEE-488.2 standard. The remaining queries are device-specific and are generated by the device designer using the functional syntax diagram and the needs of the device. The functional elements include separators, terminators, headers, and data types. These elements are discussed in the following.

4-15-1. Functional Element Summary

<Response Message> Represents a sequence of one or more <Response Message Unit> elements separated by <Response Message Unit Terminator> elements.

<Response Message Unit> Represents a single message unit sent from the device.

<Response Data> Represents any of the eleven different <Response Data> types.

<Response Message Unit Separator> Separates <Response Message Unit> elements from one another in a <Response Message>.

<Response Data Separator> Separates sequential <Response Data> elements that are related to the same header or to each other.

<Response Header Separator> Separates the header from the associated <Response Data>.

<Response Message Terminator> Terminates a <Response Message>.

<Response Header> Specifies the function of the associated <Response Data> element(s). Alpha characters mnemonically indicate the function.

<Character Response Data> A data type suitable for sending short mnemonic character strings. Generally used when a numeric data type is not suitable.

<Decimal Numeric Response Data> A data type response suitable for sending decimal integers or decimal fractions with or without exponents.

<NonDecimal Numeric Response Data> A data type suitable for sending integer numeric representation in base 16, 8, or 2. Useful for data that is more easily interpreted when directly expressed in a non-decimal format.

<String Response Data> A data type suitable for sending 7-bit ASCII character strings where the content needs to be "Hidden" (by delimiters). This element is generally used to send data for direct display on a device.

<Definite Length Arbitrary Block Response Data> A data type suitable for sending blocks of arbitrary 8-bit information when the length is known beforehand. The <Definite Length Arbitrary Block Response Data> element is defined as:

#<non-zero digit>

The value of the <non-zero digit> element equals the number of <digit> elements which follow. The value of the <digit> element taken together as a decimal integer equals the number of <8-bit data byte> elements which follow.

<Indefinite Length Arbitrary Block Response Data> A data type suitable for sending blocks of

arbitrary 8-bit information when the length is not known beforehand or when computing the length beforehand is undesirable. The <Indefinite Length Arbitrary Block Response Data> element is defined as:

#<0>

This format is especially useful when the length of the transmission is unknown or when transmission speed or other considerations prevent segmentation into definite length blocks. The use of this element requires NL+^END and forces immediate termination of the <Response Message>.

<Arbitrary ASCII Response data> A data type suitable for sending arbitrary ASCII data bytes when alternate data types are unworkable.

4-15-2. Separator Functional Element Summary

The various elements within the <Response Message> are separated by ASCII characters that were specially assigned for this purpose. These separators are discussed in the following paragraphs.

4-15-2-1. Response Message Unit Separator

The <Response Message Unit Separator> separates sequential <Response Message Unit> elements from one another when multiple <Response Message Unit> elements are sent in a <Response Message>. The <Response Message Unit Separator> is defined as:

;

4-15-2-2. Response Data Separator

The <Response Data Separator> separates sequential <Response Data> elements from one another when multiple data elements are sent. The <Response Data Separator> is defined as:

,

4-15-2-3. Response Header Separator

The <Response Header Separator> separates the <Response Header> from the <Response Data>. The <Response Header Separator> is defined as:

<Space>

4-15-3. Response Message Terminator

The <Response Message Terminator> element's function is to terminate a sequence of one or more <Response Message Unit> elements. There are three possible <Response Message Terminator> elements:

1. NL (new line);
2. NL+^END (EOI); and
3. ^END (EOI)

NL is defined as a single ASCII-encoded byte 0A (10 decimal). Leading <White Space> elements are not permitted. The instrument interprets any and all of the three terminators as semantically equivalent. No alternative encoding are allowed. Note that IEEE-P981 amendment forbids the use of CR as a <Response Message Terminator> element. This is because some controller treat CR as the end of transmission and leave the LF character in the unit, thereby creating an error in the controller.

4-15-4. Response Header

The <Response Header> is available for use by the device designer for device-specific responses. It may be used, for example, to create responses in directly resendable <Program Message Unit> format or to identify response data to the controller. There are three defined <Response Header> elements: <Simple Response Header>, <Compound Response Header>, and <Common Response Header. A <Simple Response Header> is defined as:

<Response Mnemonic>

For example, FRQ. Leading <White Space> elements are not permitted. Upper/lower case alpha characters are treated with the same semantic equivalence. <Compound Response Header> is not used in model 85 and will not be discussed here. A <Common Response Header> is defined as:

***<Response Mnemonic>**

For example, *SRE. Leading <White Space> elements are not permitted. Upper/ lower case alpha characters are treated with the same semantic equivalence.

4-15-5. Response Data

A <Response Data> functional element is used to convey a variety of response information related to the <Response Header>. The element type is determined by the eliciting query. <Non-Decimal Response Data>, <String Response Data>, and <Arbitrary Block Response Data> functional elements are not implemented in Model 85. Therefore it shall not be discussed in this manual.

Table 4-7. Response Message Format Summary

Command	Response Format (*)
FREQ?	FREQ 1.000E+3<terminator>
AMPL?	AMPL 1.00E+0<terminator>
OFFS?	OFFS 0.00E+0<terminator>
TRIG_LEV?	TLV 1.6E+0<terminator>
TRIG_SLOP?	TRIG_SLOP 0<terminator>
TRIG_PHAS?	TRIG_PHAS 00E+0<terminator>
TRIG_COUN?	TRIG_COUN 1E+0<terminator>
TRIG_PER?	TRIG_PER 1.00E+0<terminator>
SWEEP_DIR?	SWEEP_DIR 0<terminator>
START?	START 1.000E+3<terminator>
STOP?	STOP 9.999E+3<terminator>
TIME?	TIME 1.00E+0<terminator>
MARK?	MARK 5.000E+0<terminator>
EXT_REF/?	EXT_REF/ 00001<terminator>
PHAS_OFFS?	PHAS_OFFS 00E+0<terminator>
MEM_PART?	MEM_PART 1<terminator>.
SEG01?	SEG01 32767<terminator>.
SEQ_STEP?	SEQ_STEP 1<terminator>
STEP01?	STEP01 1<terminator>
SAMPLE_RATE?	SAMPLE_RATE 10.00E+6<terminator>
WAVE_FREQ?	WAVE_FREQ 305.2E+0<terminator>
WAVE_PER?	WAVE_PER 3.276E-3<terminator>
SYNC_ON_SEG?	SYNC_ON 01<terminator>
SYNC_ADD?	SYNC_ADD 00001<terminator>
Z_LEVEL?	Z_LEVEL −0.10E+0<terminator>
ARB_FILTER?	ARB_FILTER 0<terminator>
STATUS?	STATUS 000000000<terminator>
FSA?	FSA 00000000<terminator>
FSB?	FSB 00000000<terminator>

(*) NL+^END is normal terminator. Terminator may change (see paragraph 4-15-4). Response Header may be removed from string by using the "X1" commad.

4-15-5-1. Character Response Data

The <Character Response Data> functional element is used to convey information best expressed mnemonically as a short alpha or alphanumeric string. It is useful when numeric parameters are inappropriate, for example, model number and manufacturer identification.

4-15-5-2. Decimal Numeric Response Data

The <Decimal Numeric Response Data> is a flexible version of the three numeric representations as defined in ANSI X3.42-1975 - NR1, NR2, and NR3. A <Decimal Numeric Response Data> elements are defined as:

1. **NR1** elements consists of a set of implicit point representations of numeric values. i.e. (+/-)12345.

2. **NR2** elements are the representations of explicit point numeric values. i.e. (+/-)12.345.

3. **NR3** elements are representations of scaled explicit radix point numeric values together with an exponent notation. i.e. (+/-)123.456E(+/-)3.

4-16. READING FROM THE MODEL 85

The reading sequence is used to obtain, from Model 85, various <Response Message Units> such as frequency, amplitude, offset or operating modes. The <Response Message Unit> elements are placed in an output queue. The output queue may be read by device-defined queries. Such device-defined queries cause the item read to be removed from the output queue. Model 85 executes the <Program Message> elements in the order received. The output is cleared when any of the following occur:

1. Reading all the items in the output queue.
2. Upon receipt of a new <Program Message>.
3. Upon receipt of the *CLS, DCL or SDC commands.
4. Upon Power on.

IEEE-488.2 specifies that a device cannot send <Response Message> elements unless commanded to do so. This is specified as an "Unterminated Action". The "Unterminated Action" is executed when the controller attempts to read a <Response Message> from the device without first having sent a complete Query Message, including the <Program Message Terminator>, to the device. In the event of "Unterminated Action" model 85 performs the following steps:

1. Sets the Query Error bit in the Standard Event Status Register.
2. Clears the output queue.
3. Sets **brq** False.

If a read sequence is interrupted by a new <Program Message> before it finishes sending a <Response Message>, model 85 executes an "Interrupted Action". GPIB bus response is similar to the "Unterminated Action".

The reading sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The Model 85 is addressed to talk.
3. The controller sets ATN false.
4. The instrument sends the information string over the bus one byte at a time.
5. The controller recognizes that the string is terminated.
6. The controller sets the ATN line true.
7. The UNT (untalk) command is placed on the bus by the controller.

4-16-1. Interrogate Parameter Data Query

The interrogate parameter data query allows access to information concerning present operating conditions of the instrument. When the interrogate parameter data query is given, the Model 85 will transmit appropriate data string information the next time the instrument is addressed to talk. Model 85 Interrogate Parameter Data Query include:

FREQ? = Interrogate output frequency parameter.
AMPL? = Interrogate output amplitude parameter.
OFFS? = Interrogate output offset parameter.
TRIG_LEV? = Interrogate trigger level parameter.
TRIG_SLOP? = Interrogate trigger slope parameter.
TRIG_PHAS? = Interrogate trigger start phase parameter.
TRIG COUN? = Interrogate counted trigger (burst) parameter.
INT_PER? = Interrogate period of internal trigger generator parameter.

SWEEP_DIR? = Interrogate sweep direction parameter.
START? = Interrogate sweep start parameter.
STOP? = Interrogate sweep start parameter.
TIME? = Interrogate sweep time parameter.
MARK? = Interrogate sweep marker parameter.

EXT_REF/? = Interrogate frequency division parameter.
PHAS_OFFS? = Interrogate phase offset parameter.
MEM_PART? = Interrogate memory partition table parameter.
SEG01? = Interrogate memory size of segment.
SEQ_STEP? = Interrogate number of sequencer steps parameter.
STEP01? = Interrogate sequence of sequencer step.

SAMPLE_RATE? = Interrogate digital sampling rate parameter.
WAVE_FREQ? = Interrogate arbitrary wave frequency parameter.
WAVE_PER? = Interrogate arbitrary wave period parameter.

SEG01_ADDn_DAT? = Interrogate data value in address (n) of segment 01 parameter.
SYNC_ON_SEG? = Interrogate sync output location parameter.
SYNC_ADD? = Interrogate sync address parameter.
Z_LEVEL? = Z- Interrogate level amplitude parameter.
ARB_FILTER? = Interrogate filter option parameter.
STATUS? = Interrogate machine status
FSA? = Interrogate calibration failure status byte A
FSB? = Interrogate calibration failure status byte B

Interrogate Digitizer Parameters

RATE? = Interrogate digitizer sampling rate.
FULL_SCALE? = Interrogate dizitizer window level.
TRIG_SRC? = Interrogate digitizer trigger source.
INT_TRIG_LEV? = Interrogate digitizer internal trigger level.
EXT_TRIG_LEV? = Interrogate digitizer external trigger level.
DIG_TRIG_SLOP? = Interrogate digitizer edge sensitivity.
TRIG_DEL? = Interrogate digitizer trigger delay option.
PRE_TRIG? = Interrogate digitizer pre-trigger delay.
POST_TRIG? = Interrogate digitizer post-trigger delay.

For example, model 85 is asked to return frequency, amplitude, and offset parameters in a single <Response Message>

Command: FREQ?;AMPL?
Response: FREQ 1.000E+3;AMPL 1.00E+0

Table 4-7 shows the general <Response Message> format for each of the above commands. Default values are shown. These defaults are generated after an SDC or DCL commands.

4-16-2. Wavefrom Data Query

The Waveform Data Query command is used to retrieve waveform data from the instrument. There are two methods which can be used to retrieve data: 1) using the <Definite Length Arbitrary Block Response Data> format, or 2) the <Indefinite Arbitrary Block Response Data> format. The differences between the two elements were discussed previously in this section. Model 85, when interrogated for its arbitrary waveform data, can respond in either way. However, the programmer is required to let the instrument know which of the above methods is to be used when sending its data. There are two commands that can be used:

SEG01_DATA1? tells the generator that it is required to specify and send definite length block of arbitrary data. The response message from the generator will be:

SEG01_DATA#d, where "#" is followed by binary code and "d" specifies the number of binary bytes that follow.

SEG01_DATA0? tells the generator that it can transmit an undefined length of arbitrary data, as long as it terminates the arbitrary data transmission by the NL+^EOI termination option. The response message from the generator will be:

SEG01_DATA#0, where "#" is followed by binary code and "0" specifies that an undefined number of binary bytes follows.

4-16-3. Common Queries

As discussed in previous paragraphs most instruments and devices in an ATE system use similar commands which perform identical functions to avoids the problem in which devices from various manufacturers used a different set of commands to enable functions and report status. Some common commands and queries, however, are optional; most of them are mandatory. The following set of common queries are utilized in the model 85 (optional common queries that are not included in the model 85 command set will not be discussed here).

***CAL?** (Calibration Query) - causes a device to perform an internal self-calibration and generate a response that indicated whether or not the device completed the self-calibration without error. The calibration errors are stored in an internal 8-bit register which is not accessible by device-dependent or common queries. Each bit in this register represents an error in a different block within the model 85.

The generator responds to this query with a number in the range of 0 to 32767. The binary equivalent of the number represents the detected error in the calibration process. For example, a value of 1 indicates a calibration failure in the frequency circuit. Similarly, A value of 24 indicates a calibration error in the PLL and trigger circuits. A value of 0 in the response indicates that the calibration was carried out successfully. Note that complete information on calibration errors are available in the Calibration Failure Status Registers. These auxiliary status registers are discussed, in details, later in this section. The calibration query does not require any local operator interaction to function. Upon completion of *CAL?, the device returns to the state just prior to the calibration cycle. The various bits in the calibration error register are listed in the following.

Bit 0 - Frequency calibration error.
Bit 1 - Amplitude calibration error.
Bit 2 - Offset calibration error.
Bit 3 - Phase Lock calibration error.
Bit 4 - Trigger calibration error.
Bit 5 - Not used.
Bit 6 - Not used.
Bit 7 - Not used

***IDN?** (Identification Query) - Causes the generator to respond with its identity. The returned data is organized into four fields, separated by commas. The unit must respond with its manufacturer and model number in the first two fields and may also report its serial number and options in field three and four. If the later information is not available, the device must return an ASCII 0 for each. For example, model 85 response to *IDN? is TABOR,8553,0,REV1.0.

***OPC?** (Operation Complete Query) - allows synchronization between a controller and the instrument using the MAV bit in the Status Byte or a read of the Output Queue. The *OPC? query does not in any way affect the OPC Event bit in the Standard Event Status Register (ESR). Reading the response to the *OPC? query has the advantage of removing the complication of dealing with service requests and serial polls However, it has the penalty that both the system bus and the controller handshake are in temporary holdoff state while the controller is waiting to read the *OPC? query response.

***SRE?** (Service Request Enable Query) - enables the user to read the contents of the Service Request Enable register. The device returns a number in the range of 0 to 63 or 128 to 191, since bit 6 (RSQ) cannot be set. The binary equivalent of the number represents the value of the bits of the Service Request Enable Register.

***STB?** (Read Status Byte Query) - Reads the status byte containing the master summary status (MSS) bit. The device responds with an integer in the range of 0 to 255, whose binary equivalent represents the value of the bits of the status byte.

***TST?** (Self-Test Query) - Tells the device to perform an internal self-test and report back to the controller if any errors are detected. The generator responds to this query with a number. A value of 1 in the response indicates that the self-test routine has detected an error. A value of 0 in the response indicates that the self-test was carried out successfully.

4-16-4. Response Header (X)

The <Response Header> from the <Response Message> string may be suppressed using this command. When the <Response Header> is suppressed the output data string is 3 byte shorter. The <Response Header> may be suppressed using the following commands. The numbers in parenthesis represent the status number of the Response Header, as appear in the Machine Status String - STATUS.

X0 = Response header OFF (0)
X1 = Response header ON (1)

4-16-5. Response Message Terminator (Z)

To allow a wide variety of controllers to be used, the terminator can be changed by sending the appropriate command over the bus. The default value is New Line (LF), End (EOI) sequence (mode Z0). The terminator sequence will assume this default value after receiving a DCL or SDC.

The EOI (END) line on the bus is usually set low by the device during the last byte of its data transfer sequence. In this way, the last byte is properly identified, allowing variable length data words to be transmitted. The Model 85 will normally send EOI during the last byte of its data string or status word. The <Response Message Terminator> in model 85 may be programmed by sending one of the following commands. The numbers in parenthesis represent the status number of the Termination Modes, as appear in the Machine Status String - STATUS.

Z0 = New Line (LF), END (EOI) terminator (0)
Z1 = New Line (LF) terminator (1)
Z2 = END (EOI) terminator (2)

NOTES

1. Most controllers use the LF character to terminate their input sequence.
2. Some controllers may require that EOI be present at the end of the string.

4-17. DEVICE STATUS REPORTING

Device status reporting defined by IEEE-488.2 builds upon and extends the original specifications of the status byte of the IEEE-488.1 document. A complete model is defined for all status reporting. Figure 4-3 illustrates the IEEE-488.2 status reporting model showing the IEEE-488.1 status byte, which can be read by either a serial poll or Status Byte Query. Summary of related common commands and queries is given in the following.

***STB?** - Returns an NR1, which is the value of the IEEE-488.1 status byte and the MSS (Muster Summary Status) summary message.

***OPC** - Sets the Operation Complete event bit in the Standard Event Status Register when all selected pending device operation have been completed.

***OPC?** - Places a "1" in the output queue when all selected pending operations are completed which in turn cause the MAV (Message Available) summary message to be generated.

***CLS** - Clears all Event Registers summarized in the status byte.

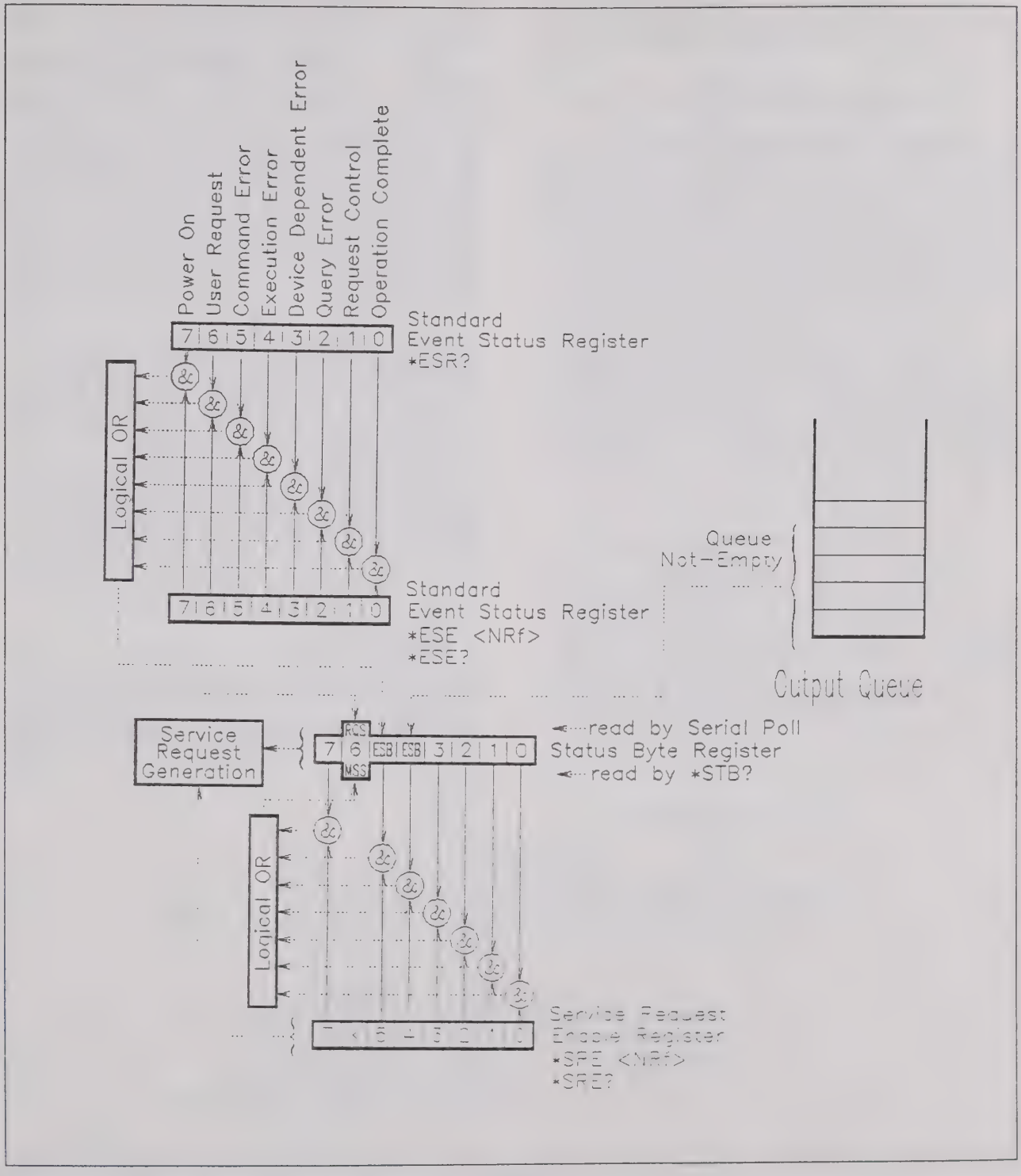


Figure 4-3. IEEE-488.2 Status Reporting Model

***ESR?** - Returns an NR1, which is the value of the Standard Event Status Enable Register.

***SRE NRf** - Sets the bits of the Service Request Enable Register.

***SRE?** - Returns an NR1, which is the value of the Service Request Enable Register.

4-18. STATUS BYTE REGISTER (STB)

The Status Byte Register contains the device's STB and RQS (or MSS) messages. IEEE-488.1 defines the method of reporting the STB and RQS, but leaves the setting and clearing protocols and semantics for the STB message undefined. The standard further defines specific device STB summary-messages.

A Muster Summary Status (MSS) message is also provided which is output as bit 6 with the STB response to a *STB? common query. The Status Byte Register is altered only when the state of the overlaying Status Data Structure is altered. The description of the various bits within the Status Byte Register is given in the following.

Bit 0 - Not used.

Bit 1 - Not used.

Bit 2 - Calibration Failure Status Summary B.

The state of this bit indicates whether or not a calibration failure in the Calibration Failure Status Byte B (FSB) have occurred. The FSB summary-message is true when a calibration error was have been detected.

Bit 3 - Calibration Failure Status Summary A. The state of this bit indicates whether or not a calibration failure in the Calibration Failure Status Byte A (FSA) have occurred. The FSA summary-message is true when a calibration error was have been detected.

Bit 4 - Message Available Queue Summary Message (MAV). The state of this bit indicates whether or not the output queue is empty. The MAV summary-message is true when the output queue is not empty. This message is used to synchronize information exchange with the controller. The controller can, for example, send a query command to the device and then wait for MAV to become true. If an application program begins a read operation of the output queue without first checking for MAV, **all system bus** activity is held up until the device responds.

Bit 5 - Standard Event Status Bit (ESB) Summary Message. The ESB summary message is an IEEE-488.2 defined message. Its state indicates whether or not one or more of the enabled ESB events have occurred since the last reading or clearing of the Standard Event Status Register.

Bit 6 - Master Summary Status (MSS)/Request Service (RQS) Bit. Its state indicate if the device has at least one condition to request service. The MSS bit is not part of the IEEE-488.1 status byte and will not be sent in response to a serial poll. The RQS bit, however, if set, will be sent in response to a serial poll.

Bit 7 - Not used.

4-18-1. Reading the Status Byte Register

The Status Byte Register can be read with either a serial poll or the *STB? common query. Both of

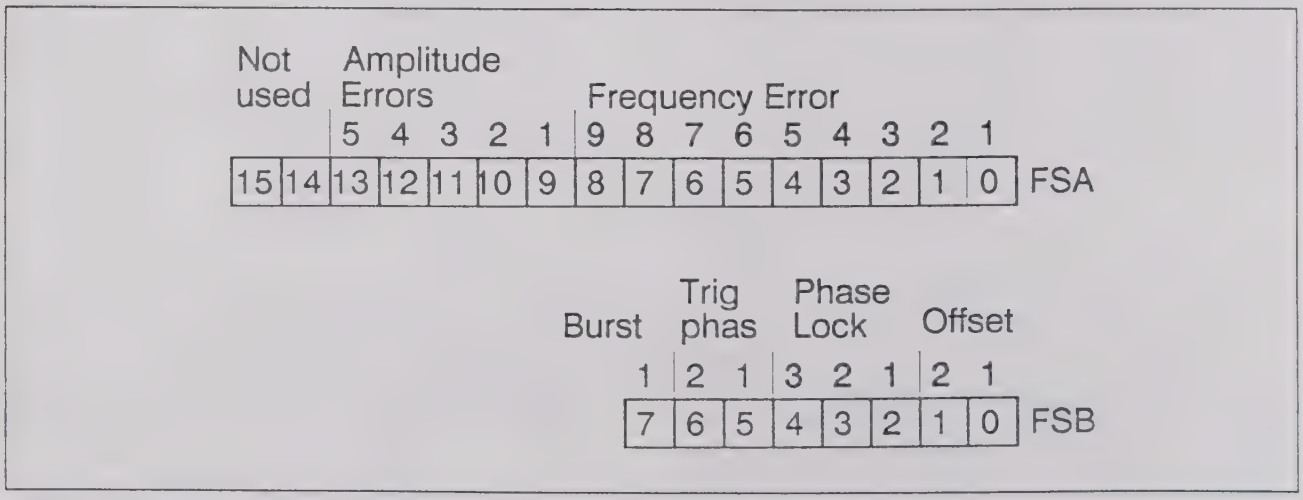

Not used
Amplitude Errors
Frequency Error
5 4 3 2 1 9 8 7 6 5 4 3 2 1
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
FSA
Burst
Trig phas
Phase Lock
Offset
1 2 1 3 2 1 2 1
7 6 5 4 3 2 1 0
FSB

Figure 4-4. Calibration failure Status Registers Interpretation.

these methods read the IEEE-488.1 STB message. The value sent for the bit 6 position is, however, dependent upon the method used.

4-18-1-1. Reading with a Serial Poll

When serial polled, the generator returns the 7-bit status byte plus the single bit RQS message. The status bye and RQS message are returned to the controller as a single data byte. The RQS message is sent on line D107 (bit 6). **RQS TRUE** means that bit 6 line is asserted (pulled to a low voltage) when the status byte is sent. The response represents the sum of the binary-weighted values of the Status Byte Register.

Reading the Status Byte Register with a serial poll sets the RQS message FALSE until a new reason for service has occurred. The STB portion of the Status Byte Register is read non-destructively. The value of the status byte is not altered by a serial poll. Once the model 85 has generated an RQS, its status byte should be read to clear the SRQ line so the controller can detect an SRQ from another device. Otherwise the instrument will continuously assert the SRQ line.

4-18-1-2. Reading With the *STB?

The *STB? common query causes the generator to send the contents of the Status Byte Register and the MSS (Master Summary Status) summary message as a single <NR1 Numeric Response Message> element. The response represents the sum of the binary-weighted values of the Status Byte Register. The *STB? common query does not alter the status byte.

4-18-1-3. Clearing the Status Byte Register

The entire Status Byte Register can be cleared by removing the reasons for service from the Auxiliary Status Registers. Sending the *CLS common command to the device after a <Program Message Terminator> and before <Query Message Unit> elements clears the Standard Event Status Register and clears the output queue of any unread messages. With the output queue empty, the MAV summary message is set to FALSE.

Methods of clearing the other auxiliary status registers are discussed in the following. The RQS message in the Status Byte Register will be FALSE. The use of the IEEE-488.1 DCL or SDC commands another method of clearing the Status Byte Register, however, in some cases it is not recommended to use this method since the entire front panel set-up is reset to factory default values.

4-18-1-4. Service Request Enable Register

The Service Request Enabling Register is an 8-bit register that enables corresponding summary messages in the Status Byte Register. Thus, the application programmer can select reasons for the model 85 to issue a service request by altering the contents of the Service Request Enable Register.

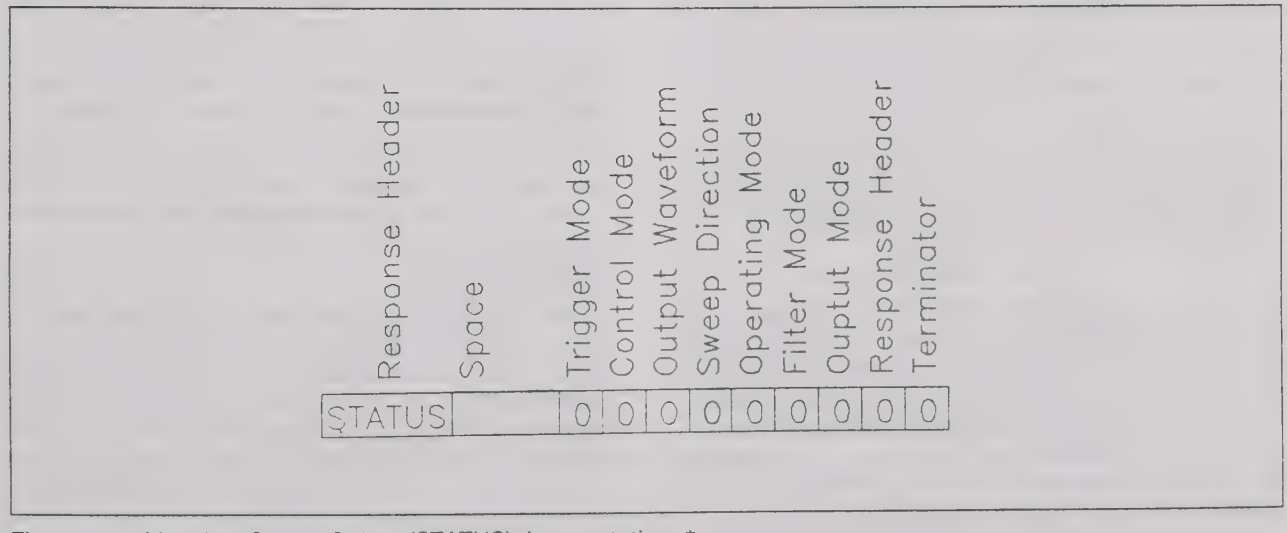


Figure 4-6. Machine Status String (STATUS) Interpretation *

The Service Request Enable Register is read with the ***SRE?** common query. The response to this query is an number that represents the sum of the binary-weighted value of the Service Request Enable Register. The value of the unused bit 6 is always zero.

The Service Request Enable Register is written using the ***SRE** common command followed by a <Decimal Numeric Program Data> element representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Service Request Enable Register is cleared by sending *SRE0. The generator always ignores the value of bit 6. Summary of *SRE messages is given in the following.

***SRE0** - No mask.
***SRE1** - No mask.
***SRE2** - No mask.
***SRE4** - Service request on FSB.
***SRE6** - Service request on FSA.
***SRE16** - Service request on MAV.
***SRE32** - Service request on ESB.
***SRE128** - Not used.

4-18-2. Standard Event Status Register (ESR)

The Standard Event Status Register is a special application of the status reporting. IEEE-488.2 document specifies the meaning of each bit of this register. The 8 bits of the SESR have been defined by the IEEE-488.2 as specific conditions which can be monitored and reported back to the user upon request.

The Standard Event Status Register is destructively read with the ***ESR?** common query. The Standard Event Status Register is cleared by a ***CLS** common command, on power-on, and when read by *ESR?.

The arrangement of the various bits within the register is firm and is required by all GPIB instruments that implement the IEEE-488.2. Description of the various bits is given in the following.

Bit 0 - Operation Complete. Generated in response to the *OPC command. It indicates that the device has completed all selected and pending operations and is ready for a new command.

Bit 1 - Request Control. This bit operation is disabled on model 85.

Bit 2 - Query Error. This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending.

Bit 3 - Device Dependent Error. This bit is set when an error in a device function occurs. For example, the following <Program Message> will cause DDE error: AMPL10E+0;OFFS10E+0. Both parameters are legal and within the specified limits, however, the function generator is unable to generate such an amplitude and offset combination. Following the Device Dependent Error the generator continues to process the input stream.

Bit 4 - Execution Error. This bit is generated if the <Program Data> element following the header is outside of the legal input range of the generator.

Bit 5 - Command Error. This bit indicates the generator received a command that was a syntax error, or a command that the device does not implement. A GET receive inside a <Program Message> will also cause a Command Error.

Bit 6 - User Request. This event bit indicates that one of a set of local controls, the MANUAL push-button in this case, has been activated. This event bit occurs regardless of the remote or local state of the device.

Bit 7 - Power On. This bit indicates that the device's power source was turned off, then on, since the last time that the register was read.

4-18-2-1. Standard Event Status Enable Register (ESE)

The Standard Event Status Enable Register allows one or more events in the Standard Event Status Register to be reflected in the ESB summary-message bit. The Standard Event Status Enable Register is an 8-bit register that enables corresponding summary messages in the Standard Event Status Register. Thus, the application programmer can select reasons for the model 85 to issue a ESB summary-message bit by altering the contents of the ESE Register.

The Standard Event Status Enable Register is read with the ***ESE?** common query. The response to this query is an number that represents the sum of the binary-weighted value of the Standard Event Status Enable Register.

The Standard Event Status Enable Register is written using the ***ESE** common command followed by a <Decimal Numeric Program Data> element representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Standard Event Status Enable Register is cleared by sending *ESE0. Summary of *ESE messages is given in the following.

***ESE0** - No mask.
***ESE1** - ESB on Operation Complete.
***ESE2** - ESB on Request Control.
***ESE4** - ESB on Query Error.
***ESE6** - ESB on Device Dependent Error.
***ESE16** - ESB on Execution Error.
***ESE32** - ESB on Command Error.
***ESE64** - ESB on User Request.
***ESE128** - ESB Power on.

4-18-3. Calibration Failure Status Registers A (FSA) and B (FSB)

The Calibration Failure Status Registers FSA and FSB are a special application of the status reporting. Figure 4-4 illustrates the calibration failure status registers. The 16 bits of the FSA contain information about calibration failures in the frequency and the amplitude circuits. The 8 bits of the FSB contain information about calibration failures in the offset, phase lock loop, trigger phase offset, and burst circuits.

The summary-messages from these registers are fed to the Status Byte register and can be monitored and reported back to the user upon request. The Calibration Failure Status Registers are destructively read with the **FSA and FSB** queries. The response to this query is a number that represents the sum of the binary-weighted value of the Calibration Failure Status Register. The Calibration Failure Status Registers are cleared by a ***CLS** common command, and when read by FSA and FSB. Power off does not clear these registers. Description of the various calibration failures is given in the troubleshooting section of this manual.

There are no enable registers for the Calibration Failure Registers which are available for the programmer. Thus, whenever a calibration error occurs, the information is immediately fed to the Status Byte Register.

4-18-4. Machine Status Register

The Machine Status Register is a special register which contains current front panel setting. The status is **non-destructively** read with the STATUS? query. The response to this query is a NR1 <Numeric Response Data> having a length of 11 digits. These digits are numeric representation of the various Machine Status options as illustrated in Figure 4-6.

4-19. FRONT PANEL ERROR MESSAGES

The process of programming the Model 85 involves the proper use of syntax. Syntax is defined as the orderly or systematic arrangement of programming commands or languages. The Model 85 must receive valid commands with proper syntax or it will:

1. Ignore the part of the <Program Message Unit> in which the invalid command appears.
2. Set appropriate bits in the Standard Event Status Register.
3. Generate an SRQ if programmed to do so.
4. Display an appropriate front panel message.

4-19-1. Command Error

An Command Error results when the instrument receives an invalid <Program Header> that has syntax error(s) such as AMP1.00. This command is can not be accepted by the instrument because it does not have such a command in its Device-Dependent Commands list. The correct command should read AMPL 1.00V. When an illegal <Program Header> is detected by the instrument, the following message will be displayed for about one second:

Command error

Consequently, the CME bit (bit 5) in the Standard Event Status Register byte will be set. The ESR byte can then be read with the *ESR? Common Query.

4-19-2. Execution Error

An Execution error occurs when the <Numeric Data> parameter associated with a legal <Program Header> command is outside the specified range limits. For example, the command AMPL 100E+0 is not a valid option because the required amplitude is outside the legal limits of the instrument. When such an error is detected, the following message will be displayed for about one second:

Execution error

Consequently, the EXE bit (bit 4) in the Standard Event Status Register byte will be set. The ESR byte can then be read with the *ESR? Common Query.

4-18-3. Device-Dependent Error

A Device-Dependent error occurs when two sets of the <Numeric Data> parameters which are associated with two legal <Program Header> elements collide. For example, the commands AMPL 10V and OFFS 7V are two legal <Program Message Unit> elements, if used separately and independently of each other. However, the instrument is incapable of generating such amplitude levels which are elevated to 7V offset. When such an error is detected, the

following message will be displayed for about one second:

Device Dep error

Consequently, the DDE bit (bit 3) in the Standard Event Status Register byte will be set. The ESR byte can then be read with the *ESR? Common Query.

4-19-4. Query Error

Query errors occurs when the programmer attempts to read new queries from the instrument without first completing the reading sequence of previous queries. When such an error is detected, the following message will be displayed for about one second:

Query error

Consequently, the QYE bit (bit 2) in the Standard Event Status Register byte will be set. The ESR byte can then be read with the *ESR? Common Query.

4-19-5. GPIB Multi-Error

The GPIB Multi-error event occurs when more than one GPIB errors has been detected by the instrument. When such an error is detected, the following message will be displayed for about one second:

GPIB Multi-error

Consequently, all of the relevant bits in the Standard Event Status Register byte will be set. They could be read and evaluated with the *ESR? Common Query.

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